

Open Research Online

The Open University's repository of research publications
and other research outputs

Proceedings of the 5th Workshop on Awareness and Reflection in Technology Enhanced Learning

Edited Book

How to cite:

Kravcik, Milos; Mikroyannidis, Alexander; Pammer, Viktoria; Prilla, Michael and Ullmann, Thomas Daniel eds. (2015). Proceedings of the 5th Workshop on Awareness and Reflection in Technology Enhanced Learning. Aachen, Germany: CEUR Workshop Proceedings.

For guidance on citations see [FAQs](#).

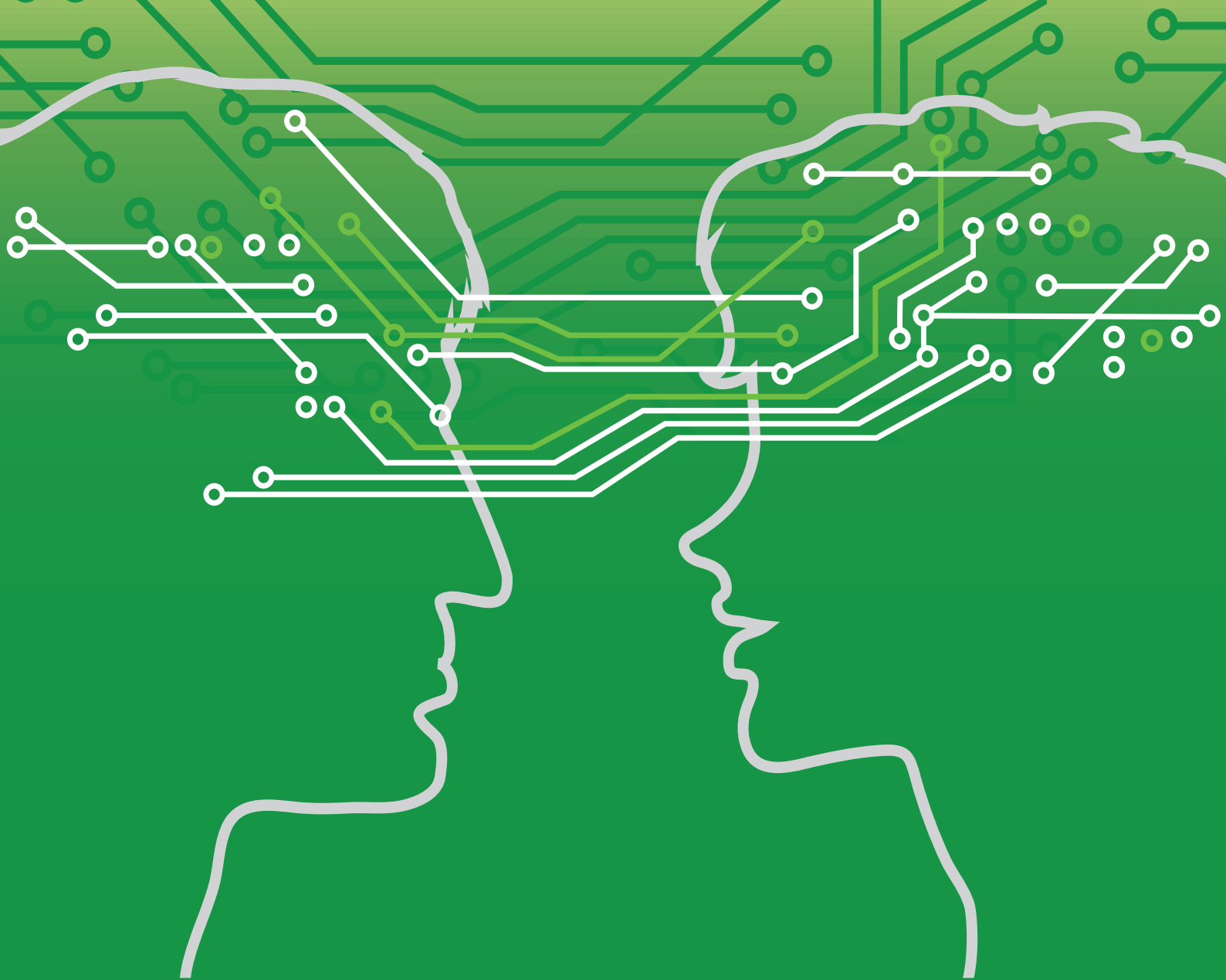
© 2015 The Editors; individual papers by the papers' authors.

Version: Version of Record

Link(s) to article on publisher's website:
<http://ceur-ws.org/Vol-1465/>

Copyright and Moral Rights for the articles on this site are retained by the individual authors and/or other copyright owners. For more information on Open Research Online's data [policy](#) on reuse of materials please consult the policies page.

oro.open.ac.uk



Proceedings of the 5th Workshop on Awareness and Reflection in Technology-Enhanced Learning

In conjunction with the 10th European Conference on Technology -
Enhanced Learning: Design for Teaching and Learning in a Networked
World

Toledo, Spain, September 15, 2015

Milos Kravcik
Alexander Mikroyannidis
Viktoria Pammer

Michael Prilla
Thomas Ullmann
(Eds.)

Please refer to these proceedings as

Milos Kravcik, Alexander Mikroyannidis, Viktoria Pammer, Michael Prilla, Thomas Ullmann (Eds.): Proceedings of the 5th Workshop on Awareness and Reflection in Technology Enhanced Learning. In conjunction with the 10th European Conference on Technology Enhanced Learning: Design for Teaching and Learning in a Networked World, Toledo, Spain, September 15, 2015. Available online at <http://ceur-ws.org/>.

© 2015 for the individual papers by the papers' authors. Copying permitted for private and academic purposes. This volume is published and copyrighted by its editors.

The front-cover was created by Harriett Cornish (The Open University, KMi).

Addresses of the editors:

Thomas Daniel Ullmann

Institute of Educational Technology
The Open University
Walton Hall
Milton Keynes
MK7 6AA
United Kingdom
t.ullmann@open.ac.uk

Viktoria Pammer

Knowledge Technologies Institute
Graz University of Technology
Inffeldgasse 21A
8010 Graz
Austria
viktoria.pammer@tugraz.at

Milos Kravcik

RWTH Aachen University
Advanced Community Information Systems (ACIS)
Ahornstr. 55
52056 Aachen
Germany
kravcik@dbis.rwth-aachen.de

Alexander Mikroyannidis

Knowledge Media Institute
The Open University
Walton Hall
Milton Keynes
MK7 6AA
United Kingdom
alexander.mikroyannidis@open.ac.uk

Michael Prilla

Institute for Applied Work Science
Ruhr University of Bochum
Universitaetsstr. 150
44780 Bochum
Germany
michael.prilla@rub.de

Awareness and reflection in technology enhanced learning

Awareness and reflection are viewed differently across the disciplines informing Technology Enhanced Learning (CSCW, psychology, educational sciences, computer science and others). The ARTEL workshop series brings together researchers and professionals from different backgrounds to provide a forum for discussing the multi-faceted area of awareness and reflection.

Through the last ARTEL workshops at EC-TEL the addressed topics are converging towards the usage of awareness and reflection in practice, its implementation in modern organisations, its impact on learners and questions of feasibility and sustainability for awareness and reflection in education and work. To reflect the growing maturity of research in ARTEL over the years the workshop particularly invited contributions that dealt with the application of awareness and reflection in practice. This is encapsulated in the workshop motto:

Awareness and Reflection in Practice: How can awareness and reflection technology become common in work practice and how does it change work practices?

Summary of the contributions

The #ARTEL15 workshop accepted 3 full papers, and 7 short paper. The accepted papers discuss awareness and reflection in formal education, outside formal education, and methods and analytics of awareness and reflection research.

Three papers focus on technology enhanced awareness and reflection in formal education.

The full paper 'Annotations as reflection amplifiers in online learning - an exploratory study' of Dominique Verpoorten, Wim Westera, and Marcus Specht discusses an annotation tool, and experiment to investigate the effects of three conditions: No annotations, free-note annotations, and structured question-based annotations. The paper provides insight into annotations as reflection amplifiers.

The short paper 'Formal concept analysis for modelling students in a technology-enhanced learning setting' of Michael A. Bedek, Michael Kickmeier-Rust, and Dietrich Albert presents the Formal Concept Analysis (FCA) framework for visualising a domain with concept lattices. FCA aims at facilitating student reflection upon their learned and still-to-learn concepts via an open learning modelling approach.

The short paper 'Learning to look - purpose and design of an awareness-raising online course in veterinary sciences; of Sophie Tasnier, Valeria Busoni, Christian Hanzen, Jeff Van de Poel, Geraldine Bolen, Catherine Delguste, Nadine Antoine, Veronique Delvaux, Tania Art, and Dominique Verpoorten discusses an approach to improve veterinary student visual awareness in use of clinical images.

Four papers discuss technology enhanced reflection and awareness outside formal educa-

tion.

The full paper 'Prompting users to facilitate support needs in collaborative reflection of Oliver Blunk, and Michael Prilla outlines a concept of how to support collaborative reflection with the help of prompts. They show an initial implementation of a prototype and an approach how to evaluate the concept.

The short paper 'A course concept for enhancing reflective learning - bringing research project results into the field' of Nils Faltin, Margret Jung describes the development of a course for learning time management for professionals. The course is based on reflective learning and practice, in a mix of coaching and computer-support.

The short paper 'Feeler: supporting awareness and reflection about learning through EEG data' of Eva Durall, and Teemu Leinonen presents a prototype which aims at supporting awareness and reflection about learning experiences through student's EEG data.

The short paper 'Mood in the city - data-driven reflection on mood in relation to public spaces' of Viktoria Pammer discusses potential benefits for stakeholders, as well as system design issues, for reflection on urban development issues with mood as entry point to reflection.

Three papers elaborate on methods and analytics of awareness and reflection research in technology enhanced learning.

The full paper 'Keywords of written reflection - a comparison between reflective and descriptive datasets' of Thomas Daniel Ullmann investigates a method to derive reflection keywords by contrasting two datasets, one of reflective sentences and another of descriptive sentences. The reflection keywords are discussed in the context of a model for reflective writing.

The short paper 'The LearnWeb formative assessment extension: Supporting awareness and reflection in blended courses' of Alana Morais, Ivana Marenzi, and Deirdre Kantz presents work about the development of visualisations summarising activity of users, groups, and classes of a collaborative sharing and working platform.

The short paper 'Deploying learning analytics for awareness and reflection in online scientific experimentation' of Alexander Mikroyannidis, Aitor Gomez-Goiri, John Domingue, Christos Tranoris, Daan Pareit, Jono Vanhie-Van Gerwen, and Johann M. Marquez-Barja introduces a European initiative for online learning and experimentation (FORGE), especially its aim to use of learning analytics to support awareness and reflection for learners and educators.

Awareness and reflection workshop series

The official workshop webpage can be found at <http://teleurope.eu/artel15>

The 5th Workshop on Awareness and Reflection in Technology Enhanced Learning (ARTEL 2015) is part of a successful series of workshops.

- 4th Workshop on Awareness and Reflection in Technology Enhanced Learning (AR-

TEL14). Workshop homepage: <http://teleurope.eu/artel14>. Proceedings: <http://ceur-ws.org/Vol-1238/>.

- 3rd Workshop on Awareness and Reflection in Technology Enhanced Learning (ARTEL13). Workshop homepage: <http://teleurope.eu/artel13>. Proceedings: <http://ceur-ws.org/Vol-1103/>.
- 2nd Workshop on Awareness and Reflection in Technology Enhanced Learning (ARTEL12). Workshop homepage: <http://www.teleurope.eu/artel12>. Proceedings: <http://ceur-ws.org/Vol-931/>.
- 1st European Workshop on Awareness and Reflection in Learning Networks (ARNets11). Workshop homepage: <http://teleurope.eu/arnets11>. Proceedings: <http://ceur-ws.org/Vol-790/>
- Augmenting the Learning Experience with Collaborative Reflection (ALECR11). Workshop homepage: <http://www.i-maginary.it/ectel2011/index.html>
- 1st Workshop on Awareness and Reflection in Personal Learning Environments (ARPLE11). Workshop homepage: <http://teleurope.eu/arple11>. Proceedings: http://journal.webscience.org/view/events/The_PLE_Conference_2011/paper.html#group_Proceedings_of_the_1st_Workshop_on_Awareness_and_Reflection_in_Personal_Learning_Environments

To stay updated about future events, to share your research, or simple to participate with other researchers, consider joining the group about Awareness and Reflection in Technology Enhanced Learning:

<http://teleurope.eu/artel>

We especially would like to thank the members of the programme committee for their invaluable work in scoping and promoting the workshop and quality assuring the contributions with their peer reviews.

September 2015

Milos Kravcik,
Alexander Mikroyannidis,
Viktoria Pammer,
Michael Prilla,
Thomas Ullmann

Organisation committee

Milos Kravcik, RWTH Aachen University, Germany
Alexander Mikroyannidis, The Open University, United Kingdom
Viktoria Pammer, Graz University of Technology, Austria
Michael Prilla, University of Bochum, Germany
Thomas Ullmann, The Open University, United Kingdom

Program committee

Philippe Dessus, Universite Pierre-Mendes-France, France
Ines Di Loreto, UTT - Universite de Technologie de Troyes, France
Eva Durall, Aalto University, Finland
Nils Faltin, IMC AG, Germany
Rebecca Ferguson, The Open University, UK
Angela Fessler, Know-Center, Austria
Michael, Kickmeier-Rust, Graz University of Technology, Austria
Kinshuk, Athabasca University, Canada
Simon Knight, The Open University, UK
Effie Law, University of Leicester, UK
Paul Lefrere, The Open University, UK
Elvira Popescu, University of Craiova, Romania
Carsten Ullrich, DFKI, Germany
Dominique Verpoorten, University of Liege, Belgium
Riina Vuorikari, European Commission JRC IPTS, Spain

Supporting projects



<http://www.mirror-project.eu>



<http://learning-layers.eu>



<http://www.laceproject.eu/>



<http://wespot-project.eu>



<http://employid.eu>



<http://www.boost-project.eu>



<http://ict-forge.eu/>

Contents

Awareness and reflection in technology enhanced learning	3
Summary of the contributions	3
Awareness and reflection workshop series	4
Organisation committee	6
Program committee	7
Supporting projects	8
Annotations as reflection amplifiers in online learning - an exploratory study <i>Dominique Verpoorten, Wim Westera, Marcus Specht</i>	11
Formal concept analysis for modelling students in a technology-enhanced learning setting <i>Michael A. Bedek, Michael Kickmeier-Rust, Dietrich Albert</i>	27
Learning to look - purpose and design of an awareness-raising online course in veterinary sciences <i>Sophie Tasnier, Valeria Busoni, Christian Hanzen, Jeff Van de Poel, Geraldine Bolen, Catherine Delguste, Nadine Antoine, Veronique Delvaux, Tania Art, Dominique Verpoorten</i>	35
Prompting users to facilitate support needs in collaborative reflection <i>Oliver Blunk, Michael Prilla</i>	43
A course concept for enhancing reflective learning - bringing research project results into the field <i>Nils Faltin, Margret Jung</i>	59
Feeler: supporting awareness and reflection about learning through EEG data <i>Eva Durall, Teemu Leinonen</i>	67
Mood in the city - data-driven reflection on mood in relation to public spaces <i>Viktoria Pammer</i>	75
Keywords of written reflection - a comparison between reflective and descriptive datasets <i>Thomas Daniel Ullmann</i>	83

CONTENTS

The LearnWeb formative assessment extension: Supporting awareness and reflection in blended courses

Alana Morais, Ivana Marenzi, Deirdre Kantz

97

Deploying learning analytics for awareness and reflection in online scientific experimentation

Alexander Mikroyannidis, Aitor Gomez-Goiri, John Domingue, Christos Tranoris, Daan Pareit, Jono Vanhie-Van Gerwen, Johann M. Marquez-Barja

105

Annotations as reflection amplifiers in online learning

– An exploratory study

Dominique Verpoorten¹, Wim Westera², Marcus Specht²

¹University of Liège, Belgium
{dvepoorten}@ulg.ac.be

¹Welten Institute, The Netherlands
{wim, spe}@ou.nl

Abstract. In a controlled experiment on the effects of frequent and local digital annotations, 137 volunteers covered an online course at 3 conditions: no/free/question-based electronic annotations. Results show no difference in performance between groups. However, analyses conducted within treatments suggest positive impacts on performance when annotation rates are taken into consideration, and coupled with other reflective enactments.

Keywords: annotations, reflection amplifiers, students set the test, widgets, split screen learning

1 Introduction

Note-taking, either when listening to lectures or reading texts, is a “totem” of teaching and learning. It seems that for centuries tutors have been expecting that students do take notes and that tutees consider note-taking as a natural activity in a scholarly life [1]. An annotation is conceived as a personal trace left by students on a pre-existing text or speech. Annotations record readers’ efforts to shape their interaction with this content. Research on note-taking has generated debates since Crawford’s early studies in this topic [2]. Promoting annotation behaviours has been a long-lasting concern in distance education. From its beginning, and long before the possibility to think about students in terms of “reflective practitioners” [3], it has been constantly recommended to design paper-based course material with large margins. This liberal use of white space [4, 5] is meant to encourage students to make analytical summary notes of what they would identify as worthy of their attention when they revise. In the 90’s, a vast body of research [6] discussed the many issues raised when moving annotation from paper-based to screen display reading. In the past few years, a renewed interest emerged for the processes of “writing on the reading” in digital activity systems, due to the novel burgeoning opportunities for searching, sharing, indexing, ordering, tagging, rating annotations in an “information enrichment” perspective [7].

While the effects of note-taking are well documented for paper-based practice [8, 9, 10], the new wave of research on digital annotations develops concerns in several directions: non-linear or linear annotation techniques [11], annotations as checklists [12], annotation sharing mechanisms [13], collaborative annotation [14, 15], tagging

as annotations [16, 17], multiple displays for annotations [18]. Results reveal various conditions under which Web-based annotation mechanisms are beneficial [19].

Beyond their variety, the new alleys of research (for an extended view on recent work, see [20]) endorse to a large extent [21] the two faces of note-taking already identified by Hartley and Davies [9]:

- as a process, annotations help to maintain attention, apprehend the material in a mentally active way and intensify the attendance to the task. By assisting in keeping learning going, they can be tokens of reflective engagement during the study task;
- as a product, annotations are stored for the future, with possibilities to be reviewed, re-structured, and enriched.

Boch and Piolat [8] use a similar distinction but labelled differently: “notes to aid reflection” (process) versus “notes to record information” (product).

1.1 Reflection Amplifiers

In this study, the annotations are conceived as “reflection amplifiers”. Following the definition by Verpoorten, Westera, and Specht [22], reflection amplifiers (*RAs*) refer to deliberate prompting approaches that offer learners structured opportunities to examine and evaluate their learning as it develops. Whereas the promotion of reflection is often associated with post-practice methods of experience recapture [23] through portfolios or learning diaries, *RAs* are nested in the study material and offered to individuals during learning activities. They induce regular mental tingling for evaluating own learning and nurturing internal feedback [24].

The concise reflection they call for further characterises *RAs*. As support to condensed reflective processes, *RAs* operate through miniature Web applications (sometimes called “widgets”) performing a single task, displaying a very clear and appropriate graphical style, and providing a single interaction point for direct provision of a given kind of data [25], here the personal annotations. In the way they are practised by learners in this study, the annotations meet the common internal characteristics of *RAs*: brevity, frequency and crisscrossing with the first-order learning activity, i.e. studying the course content.

1.2 Hypotheses

In a comparative study an online course was delivered at 3 conditions: without annotation tool, with annotation tool and free-style notes, with annotation tool and question-based notes (i.e. expressed in the format of a question on the read material). The study investigated the effects of the digital annotations – conceived as multiple short episodes of analytical reflection – upon the enhancement of the quality of learning. Two hypotheses guided the experiment.

Hypothesis 1. “The availability of an annotation tool and the assignment to use it for frequent and local notes induce higher marks at the test and an increased study time”. Short but repeated efforts of reflection are predicted beneficial to the content internal-

ization because they are seen as a way to stay analytically engaged with the supplied learning material. It is also speculated that such a reflective approach to learning has a price with regard to time spent on the material.

Hypothesis 2. “The question-based annotation strategy induces higher marks at the test than the spontaneous way of annotating”. The study includes a concern for annotation methods by challenging conventional practice of note-taking “as a student” with a different mode wherein the learner is invited to reflect “as an instructor” (details in section “The annotation methods”).

2 Method

2.1 Independent Variables

The intervention variables were the provision of an embedded annotation tool and the exposure to a strategy for frequent and local annotations.

2.2 Dependant Variables

The dependent variable was the subjects’ reflective engagement with the content, broken down into seven tangible indices:

- **Index 1:** mark at the final test (FinalTest). This index designated the score obtained at the final test taken after the study session. It measured learners’ achievement through 16 multiple-choice questions assessing knowledge and comprehension;
- **Index 2:** time spent in the course (TimeSpent). This index, measured as the number of “active ten-minute periods” in the course, was an estimate. One active period was counted each time that at least one click occurred in a time span of ten min. Longer periods were left out in an attempt to correct for the time students would spend in activities foreign to the study while still being logged into the course;
- **Index 3:** learning efficiency (LearnEff). It is fair to say that the speed of learning is an important achievement (many performance tests, e.g. IQ tests, use time as one of the main indicators). In order to incorporate this temporal dimension in the measures, the marks at the final test were related to the time spent in the course: slow learners got a lower score per unit of time than fast learners. Low-efficiency students did not necessarily receive lower marks, but they needed more time to reach their mark;
- **Index 4:** number of page views (NumberPages). The browsing behaviour, and in this case the action of re-visiting pages, was considered as an index of reflective engagement because it assumed a meta-learning decision about the need of re-reading the material;
- **Index 5:** quantity of annotations (NumberAnnot).
- **Index 6:** total number of characters for the annotations (CharactInAnnot);
- **Index 7:** number of visits (VisitDash) to the Learning Dashboard (see section “Apparatus”).

The indices FinalTest, TimeSpent, LearnEff, and NumberPages were common to the 3 conditions. NumberAnnot, CharactInAnnot, and VisitDash were premised upon the annotation tool and therefore only offered in Treatments 2 and 3.

A post-test questionnaire allowed measuring the effects of the intervention on the following additional variables: sense of control and opinion over the annotation experience.

3 Apparatus

3.1 The Online Course

The learning material of the experiment was the four-hour online course “Seks en de evolutie” (Sex and the evolution), a course signed and offered in Dutch by the Open Universiteit on the eLearning platform Moodle [26]. It was made of 30 finely illustrated pages (Fig. 1) of about 800 words each, and 4 interactive animations. It covered quite complex and interrelated notions as defined by Darwin and his followers: mutation, natural selection, genetic drift, gene flow, survival of the fittest, etc. On the whole, the course gave an in-depth account about the evolutionary theory and invited learners to use it as an interpretation grid of gender-related behaviours observable in everyday life. In the 3 conditions, the course was introduced by a welcome video and closed with the same multiple-question test.

3.2 The tool

The digital annotation tool was a comment box displayed on each page (Fig.1). It kept record of all annotations produced by the learner on this very page. The annotation tool unfolded through a click by the learner. Consistently with the length of the reading material and the action requested from learners (frequent but short notes), the surface of the tool was intentionally not large and its function deliberately restrained to the basic typing. As for pedagogy, the annotation tool was offered to promote analytical scrutiny and internalization of the learning material’s meaning by making it possible for learners to capture, within the study task, the gist of what has been read.



Figure 1. An annotation in its local context of a standard Web page of the course

In order to prevent effects of fragmentation and to also support the function of “annotations as products” [9], all local annotations were automatically recorded on a single page called “Learning Dashboard” [27], accessible at any time by the student (Fig. 2). On this dashboard, the annotations were organised by section of the course content.

Gedrag en evolutie
Gedragsstrategieën (geëvolueerd gedrag) moet evolutionair voordeel opleveren, gericht op overlev. Voorbeelden zijn reflexen, maar ook sommige fobieën.
Ultimaat en proximaat
Evolutie loopt achter de feiten aan. Welke gevolgen de bewuste ingrepen op onze voortplanting zullen verhoudingen tussen man en vrouw valt nog niet te voorspellen.
Proximaat -> de prikkel van gedrag; Ultimaat -> de oorzaak dat de proximate prikkel tot ontwikkeling komt.

Figure 2. All annotations were displayed within a learning dashboard.

3.3 The Annotation Methods

Subjects in the treatment groups were asked to make an annotation each time they (re-)visited a page. However, participants in one treatment could encode their annotations in the way they preferred (“free annotations”) while those in the other treatment were requested to produce annotations as questions (“question-based annotations”). Precisely, these participants were asked to put themselves in the shoes of the teacher and to craft questions likely to be used in a final test about the content of the page at hand. In their inventory of reflective techniques, Verpoorten et al. [22] labelled this reflective strategy: “Students set the test”, and described it as: “Learners are asked to make up the questions they might get for their exam”.

3.4 Sample and Schedule

Invitations to participate to the experiment were displayed on electronic and paper communication channels of the Open University in the Netherlands, including the homepage of the used course. Dutch dailies and magazines, as well as a psychology popular publication, also received announcements of the study. The registered persons were randomly distributed over the 3 conditions and received credentials for one version of the online course. They had one month to fill in a background questionnaire (15 min), cover the course (4 hr), take the final test (15 min) and answer the evaluation questionnaire (20 min). Out of the 361 initial respondents, 282 entered the course once at the very least but only 137 completed all steps of the study. They composed the final sample: 34 participants in Condition 1 (control group), 54 in Condition 2 (free annotations) and 49 in Condition 3 (annotations as questions). As a reward for their cooperation, they received either an iTunes voucher of 10 euros, or a three-month premium access to a mind-mapping tool (<http://www.mindmeister.com>), or a USB stick containing applications dedicated to eLearning (<http://eduapps.org>), or a free entrance to a workshop organised by the Open Universiteit.

4 Results

An alpha level of .05 was used for all statistical tests.

4.1 Measures Between Groups

Background Questionnaire. To ensure equivalence between treatments, statistical tests were performed on the data collected in the background questionnaire. The procedure exhibited an even distribution in the 3 conditions regarding:

- meta-cognitive capacities, measured with a shortened version [28] of the Meta-cognitive Awareness Inventory [29], $F(2, 134) = .27, p = .76, \eta^2 = .004$;
- self-reported familiarity with the topic, measured with a 3-point Likert scale, $\chi^2(2, N = 137) = .36, p = .83$;
- self-reported familiarity with eLearning, measured with a 3-point Likert scale, $\chi^2(2, N = 137) = 3.94, p = .13$;
- demographics: age $F(2, 134) = .4, p = .92, \eta^2 = .07$ ($X = 39, SD = 11$), sex $\chi^2(2) = .73, p = .69$ (56% female, 44% male), and education level $\chi^2(2, N = 137) = 4.8, p = .09$ (75% of the sample ticked the category “Higher education”).

Indices. An ANOVA procedure (Table 1) exhibited no significant difference between conditions regarding mean marks obtained at the final test, $F(2, 134) = .44, p = .64, \eta^2 = .007$. Significant differences emerged between conditions with regard to the:

- total time spent on the course, $F(2, 134) = 3.49, p = .03, \eta^2 = .05$;
- number of page views, $F(2, 134) = 5.29, p = .006, \eta^2 = .07$;
- learning efficiency (mark at the test/time spent in the course), $F(2, 134) = 4.76, p = .01, \eta^2 = .01$.

Table 1. Mean and standard deviation for the indices common to the three conditions

	Mark at the test			Total time spent on course (in minutes)			Page views			Learning efficiency		
	1 (N=34)	2 (N=54)	3 (N=49)	1	2	3	1	2	3	1	2	3
<i>M</i>	6.4	6	6.4	250	320	330	57	73	84	0.032	0.024	0.022
<i>SD</i>	2.3	1.7	1.8	120	110	110	23	36	44	0.018	0.014	0.012

Additional Fisher contrast tests disclosed that the differences were significant only against the control group and not between the treatments. This lack of observable divergence made it reasonable and beneficial to statistical power and clarity to redefine the treatment conditions as one single group ($N = 103$) for the following analyses.

4.2 Measures Within Treatment Group

Amount of Reflective Enactments. No correlation was found between the mark at the test and the absolute number of annotations (Index 5), characters (Index 6), page views (Index 4) and dashboard views (Index 7).

Rates of Reflective Enactments. Beyond the mere amount of reflective actions (NumberAnnot, CharactInAnnot, NumberPages, Dashvisits), the rates at which these enactments occur while studying might be an important aspect of the reflective activity. For this reason, “reflection rates” were calculated to express the displayed reflection per unit of time (minute) for different indices. These rates were obtained for each individual by dividing the quantity of reflective enactments (the different indices) by the individual time spent in the course (Index: TimeSpent). Based on these ratios, post-hoc splits were applied: subjects were categorized against the mean of the group as either high/low annotators (HA/LA via Index 5), high/low producers of annotation characters (HC/LC via Index 6), high/low browsers (HB/LB via Index 4) and high/low visitors of the learning dashboard (HD/LD via Index 7). For instance, participant 45 took 87 annotations (against an average of 43 for the whole group), produced 13958 characters (against an average of 4792), visited a content page 56 times (against an average of 78), and paid 2 visits to the dashboard (against an average of 3). According to the ratios obtained by dividing these indices by the study time (410 minutes for participant 45 against an average 328 minutes), participant 45 was labelled: HAHCLBLD (High Annotator – High producer of Characters – Low Browser – Low Dashboarder). It was assumed that this fourfold “learning DNA” captured different facets of the participant’s reflective engagement with the learning material. Assigning such a multivariate reflective engagement profile to the 103 participants revealed some new insights.

One-index Learning DNA and Mark at the Test. Table 2 displays the performance of high and low groups for each reflective enactments. When treated independently from each others, the indices deliver significant differences for index 4 (annotations), $t(101) = 2.146, p = 0.034, d = 0.35$ and for index 5 (characters in annotations), $t(101) = 2.76, p = 0.007, d = 0.35$.

Table 2. High annotators and high producers of characters outperform their low counterparts. This is not the case for high browsers and high dashboarders (index 6).

	Annotations		Characters		Dashboard		Page views	
	Low	High	Low	High	Low	High	Low	High
N	59	44	61	42	71	32	53	50
Score	5,8	6,5	5,7	6,7	6	6,3	6,1	6,1
SD	1,81	1,7	1,8	1,4	1,7	1,9	1,5	2

Two-index Learning DNA and Mark at the Test. Twofold combinations of reflective rates, for instance HA+HB (high annotation rate + high browsing rate) versus HA+LB (high annotation rate + low browsing rate) exhibited significant differences at the omnibus ANOVA, $F(3, 99) = 3.19$, $p = .027$, $\eta^2 = .088$. Table 3 shows the data for significant cases. Post hoc comparisons using the Fisher LSD test located significant mean differences between HA+HB and LA+HB ($p = 0,002$), and HA+HB and LA+LB ($p = 0,022$), but not between HA+HB and HA+LB ($p = 0,082$).

Table 3. The effect of a high rate of annotation outweighs the effect of browsing rates in twofold learning DNAs.

Twofold learning DNA	Mean mark at the test	SD	N
HA+HB	7.1	1.6	23
HA+LB	6	1.7	21
LA+HB	5.6	1.9	29
LA+LB	5.9	1.6	30

Three-index Learning DNA and Mark at the Test. The attempts made with a profile combining 3 reflection rates gave a significant mark advantage to the most reflective profile (HA+HB+HD) onto all other combinations. However, the creation of such additional combinations induced more numerous groups (Table 4) and quickly created a problem of statistical power that hampered significance tests.

Table 4. Descriptive statistics for more complex learning DNAs

Threefold learning DNA	Mean score at the test	SD	N
HA+HB+HD	7,8	0,9	5
HA+HB+LD	7	1,7	15
HA+LB+HD	5,6	2,1	8
HA+LB+LD	6,4	1,3	15
LA+HB+HD	6,2	1,7	11
LA+HB+LD	5,2	2,1	18
LA+LB+HD	6,3	2,1	8
LA+LB+LD	5,8	1,4	23

4.3 Qualitative Results

The explored qualitative aspects - overall satisfaction, sense of control, perceived intensity of reflection, - were self-reported on 5-point Likert scales in the evaluation questionnaire.

Sense of Control. Mann-Whitney test on the sense of control of the high versus low annotation rates (HA/LA) did not disclose significant differences, $U = 1225$, $p = .61$, $r = .4$. But when the browsing rate was added in the profile, the highly engaged people (HA+HB) reported a significantly higher level of control ($Mdn = 4$) compared to HA+LB ($Mdn = 3$), LA+HB ($Mdn = 3$), LA+LB ($Mdn = 3$), $\chi^2(3, N = 103) = 7.69$, $p = .04$.

Stimulation of Reflection by the Annotation Process. When asked about the effect of taking frequent annotations, 71.2% of the sample answered that reflection increased, 24.6% that it was not influenced and 4.2% that it diminished.

5 Discussion

“Put simply, reflection is about maximising deep and minimising surface approaches to learning.” [30, p. 3]. As a strategy to promote deep learning, this study asked learners to use annotations as “reflection amplifiers”, i.e. brief and repeated reflection affordances, interspersed in the learning material and activated, through the support of a dedicated widget, in support to the first-order learning task at hand. These stop-and-think episodes could be seen as a tentative instantiation of “split screen learning” [31] that consists in maintaining a dual focus on the content of the lesson and the acquisition processes that are in play. Overall, the results obtained are disappointing.

RAs do expand time on task without delivering benefit for learning achievement: the control group gets the same mark while using less time (see Table 1). Yet, the first hypothesis is not confirmed. From a strict performance-oriented viewpoint, frequent and local annotations are counter-productive.

No noticeable performance appeared between distinct uses of the annotation tool: free annotation versus question-based annotation (see section Indices). Yet, the second hypothesis is not confirmed.

This study delivers however one unexpected and intriguing pattern when the analysis operates 2 shifts of focus (see section 4.2): a) from one single reflective enactment taken in isolation (writing annotations) to multiple reflective enactments (producing a longer annotation, navigating amongst course pages, visiting one’s learning dashboard), and b) from the mere amount of these reflective enactments to their rates of use. In this case, results provide insights about ways students balance and combine the primary activity (studying the course) and the secondary reflective activities (annotations, page re-visits, dashboard views). Here, a different pattern emerges: students who write more personal annotations per unit of time than the average get a higher mark. Combinations of this reflection rate with other reflective enactments (page views, dashboard views) bring extra benefits to performance. The qualitative data also

seems to be affected by combined reflective rates: a significant effect on student's sense of control is obtained only from high aggregated rates of reflective enactments (see section "Sense of Control").

On this basis, it can be advanced that the dynamics of reflective commitment to a study task encompasses and interweaves several reflective enactments performed at a certain rhythm. It is possible that the reflective passivity of some students might be counteracted by inviting them not only to deploy more reflective actions on the material but also to accelerate their frequency.

6 Further Work

Four main issues raised in this study call for further research.

RAs and Performance. Although performance tests are not the only way to measure learning, it remains a legitimate and largely-practised way to assess mastery of content. In this perspective, final scores should reasonably be expected to reflect benefits resulting from using RAs. It has not happened here, at least in comparison with the control group. This lack of benefits from annotations contrasts with other studies in the field [32, 33, 34]. Further empirical studies can help to sort out what the effects of annotations "ought to be" from what they actually accomplish, and most importantly, in what instructional context and for what kind of learners.

RAs and Intellectual Dynamics. On a more fundamental level, the study findings, and especially those related to the effects of combined reflective enactment rates (annotations, revision of annotations, page re-visits), highlight the intellectual dynamics at work in a deep approach of study material. Further investigation is required to establish whether it could be a characteristic of high achievers and a hallmark of intellectual life in general to operate an "active study", defined as an ongoing crisscrossing between a primary learning activity and secondary reflective or meta-cognitive enactments. This periodic and persistent to-and-fro mental move offers a very different aspect of reflection than the one conveyed by portfolios or learning diaries wherein the experience and the reflection thereon are temporally distinct. If metaphors can be invoked, their complementarity presents as Lego blocks while the real-time dynamics of learning would look more after pinballs. Practical ways to evidence and sustain this interplay between cognitive and reflective landscapes [31] must be explored. Investigation of these constant shifts from a primary activity to secondary reflective activities might also benefit from the literature on interrupted tasks [35] since a stop-and-think reflective break can in certain circumstances break the flow or productively coalesce. In this context, interruption rates and optimums [36] become a pivotal notion.

RAs and Personalized Learning. An important issue for future research on annotations is also tied to the selection of relevant frames to ascertain their effects. More research needs to be undertaken to see if prompts used to amplify reflective appraisal of the study material can be related to ownership of learning and sharper feelings that learning is or becomes a "personal matter". In such an approach, personalised learn-

ing might be seen more as a consequence of seizing action and reflection affordances (37, 38, p. 151) and less as the result of a decision taken by an external agent like a teacher or an adaptive system.

RAs and vocabulary. Research in the field will benefit from a closer inspection of the use of the word “reflection” to describe cognitive operations in which the students engage. An observation of the literature devoted to reflection-in-action prompts is up to show how varied the mental processes called reflection can be. For instance, on the one hand can the kind of process invoked in the annotations be called “reflection” or does it resort to “analytical scrutiny”. On the other hand, it does not seem unacceptable to consider the step backward implied by an annotation as a form of reflection. Beyond “processes” – since one always reflects “on” something – improved specifications of “objects” of reflection critical for the growth of professional learners are needed to guide instructors in concrete instructional designs.

7 Limitations of the Study

While the results related to hypotheses 1 and 2 have been obtained through acknowledged statistical procedures and are, on this basis, totally sound, those related to the compound score of reflective rates must be taken with caution as they emerge from the pooling of the treatment groups (free annotations/question-based annotations) and the use of dichotomized data (e.g. High versus low users of the dashboard), two methodological decisions that can be discussed. With regard to pooling, Verma, Gagliardin, and Ferretti [39] highlight that a “sufficient” degree of comparability is a precondition for such pooling to be meaningful”. In this case, the comparability of the treatment groups at baseline, the identical assignment of taking a note at each page visit made to both groups, and the similar results obtained against the control group were considered sufficient to justify the pooling in an exploratory perspective. With regard to dichotomization, DeCoster, Iselin, and Gallucci [40] conclude their comprehensive review on the issue by pointing specific circumstances wherein cut-off points are acceptable, among which “the purpose of the research is to investigate how a dichotomized measure will perform in the field” (p. 364). This is the case with the work on reflective rates which has no other purpose than exploring whether frequent annotations, with no effect taken separately (hypotheses 1 and 2 are not confirmed), may, combined to other reflective enactments, reach a certain threshold, at which point they have tangible effect. The use of cut-off points, as obtained through dichotomized indicators, was also influenced by readability concerns: “big categories” (high versus low) help to prevent a “drowning by numbers” effect which can go along with unusual and complex variables such as browsing or annotation rates. Based on these motives, it appeared reasonable to proceed as described even though the use of regression analysis might have been a more straightforward method.

The decision of not to analyse the content of the annotations to compare it to the course content can also be considered as a second caveat, especially when Natural Language Processing tools, like Latent Semantic Analysis (LSA) or Latent Dirichlet Allocation (LDA), provide sufficiently good measures of it. This approach has been left to further studies for 2 reasons. On the one hand, measuring the quality of an an-

notation is difficult in itself because the learner's cognitive context around it does exist but cannot always be grasped by the researcher. Furthermore, the neglect of the fine-grained qualitative aspects was a decision flowing from the initial scope of study. Its chief postulate is that quality learning is encouraged by a permanent criss-crossing between an ongoing learning processes and explicit/structured episodes of reflection. The experimental design attempted to reproduce this intertwine somewhat artificially (that experimental design simply failed at supporting this dynamic cannot be excluded) with the annotation RA. The work was therefore more acquainted with quantitative measures than with qualitative ones. To address the latter, other instruments and methodologies – out of the initial scope of the study – should enrich the research effort. They would give insights into the actual engagement with the RA and into the quality level of the prompted reflection. Some quality check of the content of the annotations, by students and/or researchers, could also enrich the set-up, for instance by have a group where students try to answer the annotation questions just before passing the test or through annotation sharing mechanisms.

The static nature of the RA used in this study is also a limitation. The annotation tool presents as a neutral artefact that becomes available in a pre-defined way. The RA remains ignorant of the profile or the learning activities carried out by the student. In this context of self-instruction, the reflective activity is also deprived of feedback. All these limitations may qualify this RA in this context as simply inappropriate or insufficient.

Lastly, the present study takes place in a real-world context with the highs and lows of this approach. Yet, the direction of the effect in each hypothesis may be put in question as some hidden variables (e.g. motivation, self-efficacy, availability for a course taken on a voluntary basis, in the changing situations of life, etc.), beyond those controlled (see section Background questionnaire), may work as moderators.

8 Concluding remarks

A growing literature extols the importance to instil reflection and deep approaches to learning in tuition. However, practical and systematic ways to operate are not conspicuous, at least when it comes to reflection in methods of learning considered as traditional or transmissive [41], in contrast to constructivist methods (problem-based learning, collaborative learning) wherein reflection is claimed to be “built-in” [42, 43, 44]. This study inquired the question: how to induce a more thoughtful autonomous study of learning material? To answer, the experimental setting artificially increased the number of annotations, conceptualised as frequent tinglings for reflection while reading and purposed to support a persistent dynamic mental engagement with the reading material. An assumption guided this work: that such a kind of active and reflective posture to learning, which constantly articulates the cognitive and the meta-cognitive landscapes, is a key feature of intellectual life. The experimental setting presented here was a simplified attempt to mimic and externalize such fundamental inner dynamic processes via an annotation tool. Eventually, annotations taken alone did not really measure up. However, some elements of the study suggest that the frequency and the aggregation of different reflective behaviours can be worth exploring further in connection to quality learning.

References

1. Jackson, H. J.: *Marginalia: Readers writing in Books*. Yale University Press, New Haven, (2001)
2. Crawford, C. C.: Some experimental studies of the results of college note-taking. *Journal of Educational Research*, 12, 379-386 (1925)
3. Schön, D.: *The Reflective Practitioner: How professionals think in action*. Temple Smith, London (1983)
4. Commonwealth: *Creating learning materials for open and distance learning - A handbook for authors and instructional designers*. Commonwealth of Learning, Vancouver (2005)
5. Open University: *Guide for the Appointment of Tutorial and Counselling Staff*. Open Teaching Toolkits, Open University (1991-1994)
6. Dillon, A.: Reading from paper versus screens: a critical review of the empirical literature. *Ergonomics* 35(10), 1297-1326 (1992). doi: 10.1080/00140139208967394
7. Priolli, P. (2007): *Information Foraging Theory: Adaptive Interaction with Information*. Oxford University Press, Oxford-New York (2007)
8. Boch, F., Piolat, A.: Note taking and learning: A summary of research. *The WAC Journal* 16, 101-113 (2005)
9. Hartley, J., Davies, I. K.: Note-taking: A critical review. *Innovations in Education & Training International* 15(3), 207-224 (1978)
10. Slotte, V., Lonka, K.: Note-taking review – Practical value for learners. *Arob@se* 1-2, 79-86 (2003)
11. Makany, T., Kemp, J., Dror, I. E.: Optimising the use of note-taking as an external cognitive aid for increasing learning. *British Journal of Educational Technology* 40(4), 619-635 (2009). doi: 10.1111/j.1467-8535.2008.00906.x
12. Degani, A., Wiener, E. L.: *Human factor of flight-deck checklists: The normal checklist*. NASA, Moffett Field (1990).
13. Van der Baaren, J., Schuwer, R., Kirschner, P., Hendriks, M.: Finding your way into an open online learning community. *Journal of Interactive Media in Education*, 4 (2008).
14. Hwang, W.-Y., Chen, N.-S., Shadiev, R., Li, J.-S.: Effects of reviewing annotations and homework solutions on math learning achievement. *British Journal of Educational Technology* 42(6), 1016-1028 (2011).
15. Kam, M., Wang, J., Iles, A., Tse, E., Chiu, J., Glaser, D., Canny, J.: *Livenotes: a system for cooperative and augmented note-taking in lectures*. Paper presented at the CHI '05: Proceedings of the SIGCHI conference on Human factors in computing systems, Portland, Oregon, USA (2005)
16. Glahn, C.: *Contextual support of social engagement and reflection on the Web*. PhD series, Open Universiteit, Heerlen, The Netherlands (2009).
https://www.ou.nl/Docs/Onderzoek/Promoties/2009/Christian_Glahn_thesis.pdf
17. Verpoorten, D., Glahn, C., Chatti, A., Westera, W., Specht, M.: Self-Reported Learning Effects of a Tagging Activity Carried out in a Personal Learning Environment (PLE) by Secondary-School Pupils. *International Journal for Cross-Disciplinary Subjects in Education* 2(1), 276-284 (2011).
18. Schilit, B., Golovchinsky, G., Price, M.: *Beyond paper: supporting active reading with free form digital ink annotations*. Paper presented at the Conference on Human factors in computing systems, Los Angeles, CA, USA (1998). <http://orbi.ulg.ac.be/handle/2268/151959>
19. Kawase, R., Papadakis, G., Herder, E., Nejd, W.: *Creation and Use of Annotations in Different Usage Contexts*. L3S Research Center Hannover (NA).
<http://stellarnet.eu/d/1/2/images/a/ae/Sss1.pdf>

20. Hwang, W.-Y., Hsu, G.-L.: The Effects of Pre-Reading and Sharing Mechanisms on Learning with the Use of Annotations. *Turkish Online Journal of Educational Technology – TOJET* 10(2), 234-249 (2011). <http://files.eric.ed.gov/fulltext/EJ932242.pdf>
21. Glover, I., Xu, Z., Hardaker, G. Online annotation – Research and practices. *Computers & Education* 49(4), 1308-1320 (2007). doi: 10.1016/j.compedu.2006.02.006
22. Verpoorten, D., Westera, W., Specht, M.: Reflection amplifiers in online courses: a classification framework. *Journal of Interactive Learning Research* 21(4), 654-666 (2010) <http://orbi.ulg.ac.be/handle/2268/151374>
23. Boud, D., Keogh, R., & Walker, D.: *Reflection, Turning Experience into Learning*. Kogan Page, London (1985)
24. Butler, D. L., Winne, P. H.: Feedback and Self-Regulated Learning: A Theoretical Synthesis. *Review of Educational Research* 65(3), 245-281 (1995)
25. Verpoorten, D., Westera, W., Specht, M.: Infusing reflective practice in eLearning courses - can widgets help? *International Journal of Technology Enhanced Learning* 3(1), 93-109 (2011). <http://orbi.ulg.ac.be/handle/2268/151348>
26. Eshuis, J.H., Goltstein, G.P.: *Seks en de evolutie*. Open Universiteit Nederland, Heerlen (2007). <http://www.ou.nl/eCache/DEF/2/22/850.html>
27. Verpoorten, D., Westera, W., Specht, M.: A first approach to “Learning Dashboards” in formal learning contexts. Paper presented at the ADVTEL workshop (1st International Workshop on Enhancing Learning with Ambient Displays and Visualization Techniques) at EC-TEL 2011, Palermo, Italy (2011). <http://orbi.ulg.ac.be/handle/2268/151988>
28. Bijker, M., Van der Klink, M., Boshuizen, H.: Modeling self-efficacy, self-regulation, self-directed learning and career processes of adult professionals and relations with learning outcomes and labour market success. Paper presented at the 5th EARLI-SIG14 Learning and Professional Development, Munich, Germany (2010)
29. Schraw, G., Dennison, R.: Assessing metacognitive awareness. *Contemporary Educational Psychology* 19, 460-475 (1994).
30. Hinett, K.: *Improving Learning through Reflection*. York: Higher Education Academy, York (2002)
31. Claxton, G.: Expanding the capacity to learn: a new end for education? Opening keynote address presented at the British Educational Research Association Annual Conference, University of Warwick, UK. (2006). http://www.buildinglearningpower.co.uk/includes/pdf_library/GC_BERA_Keynote.pdf
32. Hwang, W.-Y., Wang, C.-Y., Sharples, M.: A Study of Multimedia Annotation of Web-Based Materials. *Computers and Education*, 48(4), 680-699 (2007)
33. Nokelainen, P., Miettinen, M., Kurhila, J., Floréen, P., Tirri, H. : A shared document-based annotation tool to support learner-centred collaborative learning. *British Journal of Educational Technology* 36(5), 757-770 (2005)
34. Slotte, V., Lonka, K.: Review and process effects of spontaneous note-taking on text comprehension. *Contemporary Educational Psychology*, 24, 1-20 (1999)
35. Mark, G., Gudith, D., Klocke, U. The cost of interrupted work: More speed and stress. Paper presented at the 26th annual SIGCHI Conference on Human factors in computing systems, Florence, Italy (2008). doi: 10.1145/1357054.1357072
36. Palanque, P., Winckler, M., Martinie, C.: A Formal Model-Based Approach for Designing Interruptions-Tolerant Advanced User Interfaces. *Computational Intelligence* 340, 143-169 (2011). doi 10.1007/978-3-642-14562-9_8
37. Verpoorten, D., Glahn, C., Kravcik, M., Ternier, S., Specht, M.: Personalisation of learning in virtual learning environments. *Learning in the Synergy of Multiple Disciplines*. Pro-

- ceedings 4th European Conference on Technology Enhanced Learning, EC-TEL 2009, 52-66 (2009). <http://orbi.ulg.ac.be/handle/2268/151458>
38. Crawford, M.: The world beyond your head. How to flourish in an age of distraction. Viking, Great Britain (2015)
 39. Verma, V., Gagliardi, F., Ferretti, C.: On pooling of data and measures. DMQ 84 (2009)
 40. DeCoster, J., Iselin, A.-M. R., Gallucci, M.: A conceptual and empirical examination of justifications for dichotomization. *Psychological Methods* 14(4), 349-366 (2009). doi: 10.1037/a0016956
 41. Terhart, E.: Constructivism and teaching: a new paradigm in general didactics? *Journal of Curriculum Studies* 35(1), 25-44 (2003).
 42. Kirschner, P. A., Sweller, J., Clark, R. E.: Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist* 41(2), 75-86 (2006)
 43. Hmelo-Silver, C. E., Duncan, R. G., Chinn, C. A.: Scaffolding and Achievement in Problem-Based and Inquiry Learning: A Response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist* 42(2), 99-107 (2007). doi: 10.1080/00461520701263368
 44. Sweller, J., Kirschner, P. A., Clark, R. E.: Why Minimally Guided Teaching Techniques Do Not Work: A Reply to Commentaries. *Educational Psychologist* 42(2), 115-121 (2007). doi: 10.1080/00461520701263426

Formal Concept Analysis for Modelling Students in a Technology-enhanced Learning Setting

Michael A. Bedek, Michael Kickmeier-Rust, and Dietrich Albert

Knowledge Technologies Institute, Graz University of Technology, Austria

{michael.bedek, michael.kickmeier-rust, dietrich.albert}@
tugraz.at

Abstract. We suggest the Formal Concept Analysis (FCA) as theoretical backbone in technology-enhanced learning settings to support a students' learning process in two ways: i) by engaging with concept lattices, the structure of the knowledge domain and the interrelations of its concepts become explicit, and ii) by providing visual feedback in form of open learner modelling, the student's reflection on the own strengths and weaknesses is facilitated. For teachers, the FCA provides intuitive visualizations for a set of pedagogically relevant questions, concerning the performance of students on the individual- as well as on the class-level.

Keywords: Formal Concept Analysis, Learning Analytics, Visualizations, Learner Modelling

1 Introduction

The increasing availability of comprehensive technology-enhanced learning (TEL) environments or single educational tools and apps enables students to easily advance their knowledge without direct support from a teacher. However, teachers are challenged by the need to provide appropriate learning resources and to keep up with students' learning progress without reverting to exams or tests [1]. Learning analytics and educational data mining are two highly interrelated research fields that aim to help teachers and educators to make previously hidden insights explicit (e.g. [2]). When applying learning analytics and educational data mining in schools, it is of high importance to meet the requirements of teachers and students. Teachers usually want to have user-friendly tools that help them to reduce the time required for personalized assessment and tailored competence development of their students.

We suggest the Formal Concept Analysis (FCA) as a framework for addressing these requirements. A so-called FCA-tool has been developed in the course of the EU-funded project weSPOT (<http://wespot.net/home>), which provides a *Working Environment with Social and Personal Open Tools* to support students in developing their inquiry based learning skills. In the context of weSPOT, the FCA-tool is mainly used by students by guiding them through a knowledge domain, predefined and en-

riched with learning resources by their teacher. For a more technical description of the FCA-tool's features see [3]. In weSPOT, the FCA-tool supports learners by enabling domain and open learner modelling. The fields of application of the FCA in general, and the FCA-tool in particular, have been extended in the course of the LEA's BOX project (<http://leas-box.eu/>) which stands for Learning Analytics Toolbox. In the context of LEA's BOX, the FCA-tool is mainly used by teachers for student modelling and visualization of educational data. By applying the formal concept analysis with students' performance data, a set of pedagogically relevant questions for teachers can be addressed and visualized.

2 Formal Concept Analysis

The FCA describes concepts and concept hierarchies in mathematical terms, based on the application of order and lattice theory [4]. The starting point is the definition of the formal context K which can be described as a triple (G, M, I) consisting of a set of objects G , a set of attributes M and a binary relation I between the objects and the attributes (i.e. " $g I m$ " means "the object g has attribute m "). A formal context can be represented as a cross table, with objects in the rows, attributes in the columns and assigned relations as selected cells. An example of a formal context is shown in Fig. 1. This formal context has been created by the FCA-tools *Editor View*. Teachers use the *Editor View* to define the formal context and to add learning resources (URLs or files) which can be assigned to both objects and attributes, respectively.

	is toxic	hatched from egg	is able to fly	lives in/ on the water	is able to swim	live birth	performs photosynt...	bear fruits
Bumble-bee	✓	✓	✓					
Bee	✓	✓	✓					
Tree frog		✓		✓	✓			
Goldfish				✓	✓			
Root vole						✓		

Fig. 1. FCA-tool's *Editor View* for creating a domain with objects, attributes, and relations.

In order to create a concept lattice, for each subset $A \in G$ and $B \in M$, the following derivation operators need to be defined:

$$A \mapsto A' := \{m \in M \mid g I m \text{ for all } g \in A\}, \text{ which is the set of common attributes of the objects in } A, \text{ and}$$

$$B \mapsto B' := \{g \in G \mid g I m \text{ for all } m \in B\}, \text{ which is the set of objects which have all attributes of } B \text{ in common.}$$

A formal concept is a pair (A, B) which fulfils $A' = B$ and $B' = A$. The set of objects A is called the extension of the formal concept; it is the set of objects that encompass the formal concept. The set B is called the concept's intension, i.e. the set of attributes, which apply to all objects of the extension. The ordered set of all formal concepts is called the concept lattice $\mathfrak{B}(K)$ (see [5] for details), which can be represented as a labelled line diagram (see Fig. 2).

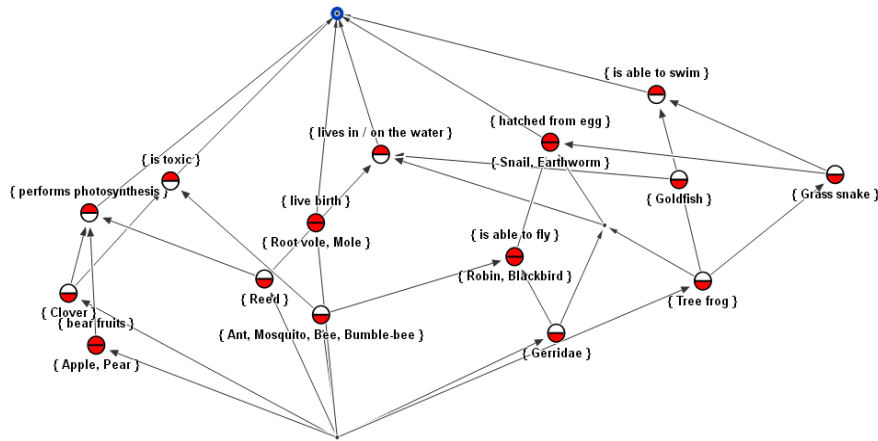


Fig. 2. Concept lattice

The concept lattice shown in Fig. 2 has been created by the FCA-tool's *Lattice View*. Every node represents a formal concept. The extension A of a particular formal concept is constituted by the objects that can be reached by descending paths from that node. As an example, the node with the label "Goldfish" has the extension {Goldfish, Tree frog}. The intension B is represented by all attributes that can be reached by an ascending path from that node. In the example above, the intension consists of {is able to swim, lives in / on the water}.

3 Domain Learning and Open Learner Modelling

Once the teacher has created the formal context, students can explore the resulting concept lattice by engaging in interactive graph visualizations (see Fig. 2). By selecting a node, the corresponding concept's extension and intension are illustrated in a highlighted manner. The concept lattice makes the structure of the knowledge domain and the interrelations of its concepts explicit. Similar as for concept maps, this kind of graphic organizer aims to facilitate meaningful learning by activating prior knowledge and illustrating its relationship with new concepts [6].

In case the teacher also assigned learning resources to the objects and attributes in the FCA-tools *Editor View* open learner modelling can be supported (see Fig. 3). Visualizations of open learner models (for an overview see [7]) are aiming to facilitate reflection on the side of the students and to support teachers to better understand strengths and weaknesses of their students.

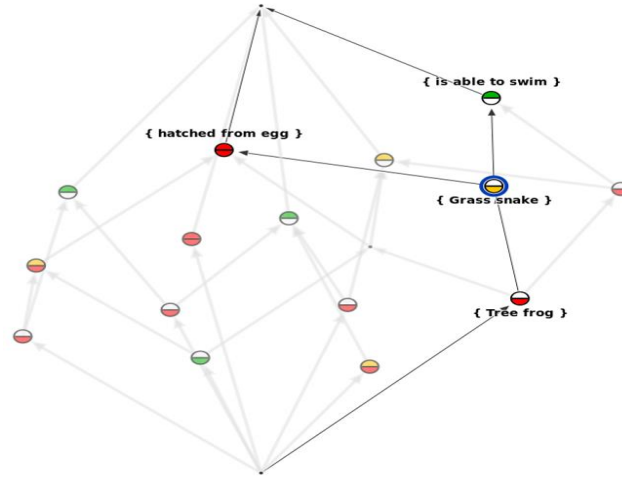


Fig. 3. FCA-tools *Lattice View* for visualizing domain- and learner models.

The FCA-tool's *Lattice View* applies the often-used traffic-light analogy (see e.g. [8]) to show the student the extent to which he or she already consumed learning resources.

4 Applying the FCA(-tool) as a teacher

Similar as [9] who were the first who applied the FCA with students and their performance data we suggest formal contexts with student as “attributes” and problems or test-items as “objects”. The relation between these two sets means “student m has solved test item g ”.

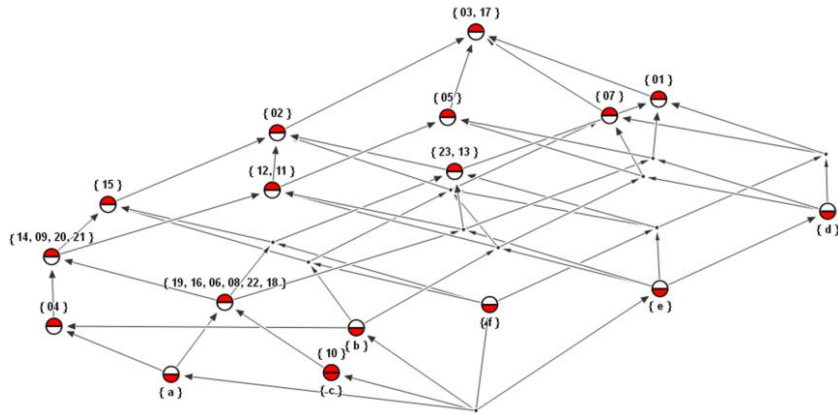


Fig. 4. Concept lattice with students as attributes (numbers from 01 to 23) and test items (letters a , b , c , d , e , and f) as objects (data reported by [10]).

An example of a concept lattice which results from such a formal context is shown in Fig. 4 (the data has been reported by [10]). As briefly outlined in the following sections, such a concept lattice visualizes answers to a set of pedagogical questions which are of high interest for teachers.

4.1 Depicting information from the formal concepts extensions and intensions

As mentioned above, the set of test items which have been solved by a particular student can be directly depicted from the extension of the formal concept with the students' label assigned to it. As an example in Fig. 4, student 10 is the only one who solved only a single test item, *c*, and students 03 and 17 (assigned to the top element of the concept lattice) mastered all problems. When clicking on a particular node the formal concept's extension and intension is highlighted. As an example shown in Fig. 5 (left side), the student 04 has successfully mastered the test items *a* and *b*.

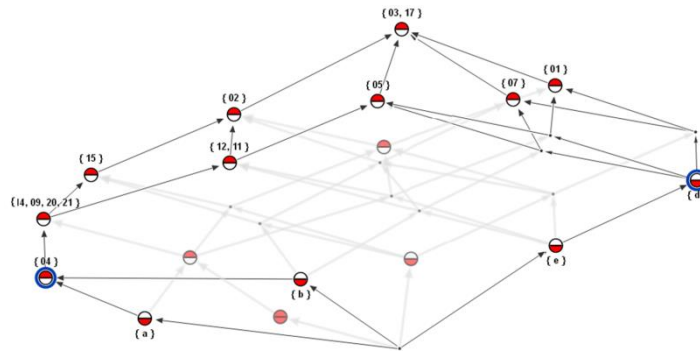


Fig. 5. The extension represents the set of test items solved by a student (see student 04) and the intension represents the set of students who solved the particular test item (see test item *d*)

The intension of a formal concept which has an object-label assigned to it indicates the set of students which have successfully mastered the according test item. As an example, the problem *d* in Fig. 5 (right side) has been solved by the students 01, 03, 05, 07 and 17. As it can be also seen, this formal concept located above the formal concept with the object-label *e* assigned to it. This means, that all students who solved item *d* were also able to solve item *e*.

4.2 Highlighting overlaps and differences of students performances

The performances of two or more students can be compared when examining the intensions of the formal concepts with the according attribute-labels. As an example, the students 07 and 15 mastered different subsets of problems (see Fig. 4): Student 07 mastered the items *b*, *d*, *e* and *f* while student 15 mastered the items *a*, *b*, *c*, and *f*. Both students mastered items *b* and *f* (which is the set closure of their intensions) and together they mastered all problems (which is the set union of their intensions).

As a teacher, such kind of information might be of great interest since it helps to effectively arrange groups of students when aiming for collaborative, peer-learning (where students learn together in groups). In the example above, the students 07 and 15 together could be tutors for other students.

4.3 Visualizing a classrooms' learning progress over time

The concept lattices shown in Fig. 4 and Fig. 5 are the result of a formal context which is an evaluation of the students' performances at a certain point in time. However, in some cases it might be of great interest for a teacher to observe the learning progress over a longer period of time. Ideally, all students might be able to master all items at the end of course or the semester. In such a case, all cells in the formal context would be filled with crosses. This would result in a concept lattice with only a single formal concept. Fig. 6 exemplifies such a learning progress over time. The concept lattice in the middle results from adding one solved item to the students' performance states (except for the students 03 and 17). The concept lattice on the right results from adding another item to the student's performance states.

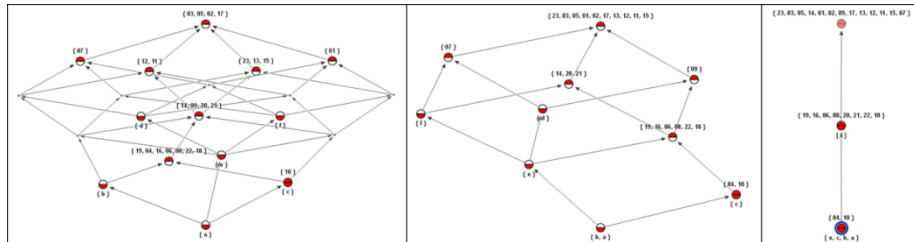


Fig. 6. Concept lattices changing over time reflect the learning progress of the class of students

In general, the visual appearance of the concept lattice gives a first impression of the student's coherence with respects to their performance: A concept lattice which looks "complex" due to a large amount of formal concepts is an indication for a high diversity among the students' performances.

5 Discussion and Outlook

In the previous sections, we suggested to apply the FCA to support students and teachers. Students apply the FCA, respectively the FCA-tool, to learn a knowledge domain by interacting with the concept lattice which makes previously hidden interrelationships between the domain's concepts explicit. In addition to that, a student's reflection upon his or her learned and still-to-learn concepts is supported by an open learning modelling approach. Summative evaluation studies on the effect of these pedagogical principles are still ongoing in the course of the weSPOT project.

In the context of LEA's BOX, also teachers apply the FCA(-tool) to visualize the answers to a set of pedagogical questions which are of high interest for them. These

pedagogical questions described in this paper are the result of small focus groups and interviews with teachers in the early phase of the LEA's BOX project. The resulting visualizations as shown above are currently in the spotlight of formative, qualitative evaluation studies with small focused groups of teachers. Current work on the technical side of the project focuses on the development of interactive visualizations which can be easily used by teachers in the classroom. Early feedback of teachers concerns the complexity of the concept lattices, in particular when dealing with a great amount of problems (respectively competences and skills). Conceptual research and the elaboration of ideas on how to reduce this complexity without reducing the amount of information which can be extracted and deduced from the visualizations will be the main focus of our work in the near future.

Acknowledgement. The research leading to these results has received funding from the European Community's Seventh Framework Program (FP7) under grant agreements no 318499 (weSPOT project) and no. 619762 (LEA's BOX). This document does not represent the opinion of the EC and the EC is not responsible for any use that might be made of its content.

References

1. Shute, V.J.: Simply Assessment. *International Journal of Learning, and Media*. 1, 1-11 (2009)
2. Steiner, C., Kickmeier-Rust, M., Albert, D.: Learning Analytics and Educational Data Mining: An Overview of Recent Techniques. In: *Proceedings of the EC-TEL 2014 workshop 'Learning analytics for and in serious games'*, pp. 6 – 15, (2014)
3. Bedek, M., Kopeinik, S., Pruenster, B., Albert, D.: Applying the Formal Concept Analysis to introduce guidance in an inquiry-based learning environment. In: *15th IEEE International Conference on Advanced Learning*. IEEE Press, New York (2015, in press)
4. Wille, R.: Restructuring lattice theory: an approach based on hierarchies of concepts. In: Rival, I. (ed.) *Ordered sets*, pp. 445-470. Reidel, Dordrecht-Boston (1982)
5. Wille, R.: Formal Concept Analysis as Mathematical Theory of Concepts and Concept Hierarchies. In: Ganter, B., Stumme, G., Wille, R. (eds) *Formal Concept Analysis*, pp 1-34. Springer, Berlin (2005)
6. Nesbit, J.C., Adesope, O.O.: Learning With Concept and Knowledge Maps: A Meta-Analysis. *Review of Educational Research*. 76, 413–448 (2006)
7. Bull, S., Kay, J.: Open Learner Models. Nkambou, R., Bordeau, J., Miziguchi, R. (eds.) *Advances in Intelligent Tutoring Systems*, pp. 318-388. Springer, Heidelberg: Springer (2010)
8. Arnold, K.E., Pistilly, M.D.: Course Signals at Purdue: Using learning analytics to increase student success, In: *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge*, pp. 267-270. ACM, New York (2012)
9. Rusch, A., Wille, R.: Knowledge spaces and formal concept analysis. In: Bock, H.H., Polasek, W. (eds.) *Data analysis and information systems: Statistical and conceptual approaches*, pp. 427-436. Springer, Berlin (1996)
10. Korossy, K.: Modeling Knowledge as Competence and Performance. In: Albert, D., Lukas, J. (eds.) *Knowledge Spaces: Theories, Empirical Research, and Applications*, pp. 103-132. Springer, Mahwah, NJ (1999)

Learning to Look – Purpose and Design of an Awareness-Raising Online Course in Veterinary Sciences

Sophie Tasnier, Valeria Busoni, Christian Hanzen, Jeff Van de Poël, Géraldine Bolen, Catherine Delguste, Nadine Antoine, Véronique Delvaux, Tania Art, and Dominique Verpoorten

University of Liège, Belgium

{sophie.tasnier, vbusoni, christian.hanzen, jvandeпоel, gbolen, cdelguste, nadine.antoine, vdelvaux, tatania.art, dvepoorten}@ulg.ac.be

Abstract. This paper reports on a work in progress: an online self-instruction course created to stimulate students' awareness processes when dealing with pictures. Using non-clinical material, the "Learning to Look" course was designed as a preliminary training to the observation of histological sections, radiological graphs, and other specialized visual material. Following a presentation of the project, salient results of a feedback questionnaire completed by 382 students about their experience of the course are provided.

Keywords: awareness, veterinary sciences, observation, visual skills, visual acuity, attentional training, clinical images, multimodal literacy, learning to look

1 Introduction

Observation is a core-competency for veterinarians and more generally for health professionals [1, 2, 3]. Correct prognosis and appropriate treatment always depend on correct identification of animal behaviors, signals, and symptoms. This "ability to look" is nowadays also directed at a growing range of images (in radiology, cardiology, endoscopy, microscopy, etc.) more and more invoked in daily veterinary practice. This context spurs the need of a renewed pedagogical reflection on appropriate ways to improve veterinary student visual awareness in use of clinical images.

2 Observed Problems

The "Learning to Look" project stemmed from observations made by a group of teachers from the University of Liege:

- students have problems when confronted with visual material like histological sections, radiological graphs or dynamic recordings of clinical situations;
- despite its importance and its indirect assessment in some courses, noticing what is in an image is not a skill taught in a targeted and coordinated way;
- several courses train somehow abilities to see. However, the specific visual material and activities they use hamper a generic and methodical approach of picture exploitation (to look, to spot, to describe, to analyze, to interpret).

3 An Online Course

To tackle these problems, an online course called “Learning to look” (“Savoir voir”) was designed and offered, on a voluntary basis, to 630 bachelor and master students, as a preparation for specific courses and practical sessions dealing with clinical images. The course was divided in 3 modules: Module A - Learning to look at an image, Module B - Learning to describe an image, and Module C - Learning to interpret an image. This paper focuses on Module A which matches the general topic of ARTEL workshop: awareness.

The main purpose of Module A was to train students’ ability to apply sustained attendance to an image (see examples in Fig. 1, 2, 3) in order to identify things of interest within (or possibly absent from) it. (“Recall that the basic concept at the root of attention is selection: we pick something out from the flux of the available”, [4, p. 86]).

Beyond this training of “visual acuity” the module also intended to foster awareness to own attentional processes in learning activities prescribing to exercise control over how and what to look.

In the Module A of the “Learning to Look” course, these attentional processes were applied by students onto unspecific pictures (i.e. non-clinical images and without relation to existing courses). This choice was deliberate and made for two reasons. On the one hand, transversal benefits (not related to a precise type of picture) were targeted. On the other hand, using arbitrary imagery at baseline provided a soft entry in the attentional training process. Medical visuals were steadily incorporated in subsequent modules of the eLearning course.

The course was released on the institutional eLearning platform Blackboard. Students got 45 days (from March 1st to mid-April 2015) to cover it according to a self-study modality.

4 Instructional Design

The instructional design of Module A presented as a series of pictures that students had to observe. A question (see examples in captions of Fig. 1, 2, 3) challenged them to find, match, or discriminate visual elements, with a time limit in some cases (a mean time was calculated from the performance of a group of students who acted as beta-testers of the course). For each picture, students answered the question either by clicking on sensible spot(s) on the image or by selecting one option in a list. They received an immediate feedback on their answer's correctness and on the time they had spent on the image (compared to the yardstick). Feedback was also enriched with pieces of advice (e.g. "You did not find all relevant elements. Try to scan the image in a systematic way" or "You did not spot the elements fast enough. Keep in mind that speed is also a parameter of visual performance"). Following the completion of all exercises, students received a compound awareness score.

Pictures were selected in existing material [e.g. 5] and displayed in an Adobe Captivate format in order to benefit from responsive design (mouse-over and embedded countdown features) and easy quizzing. Module A was structured in 3 gradual pools of 10 to 15 exercises prompting various aspects of awareness according to a semiological approach which assumes that because the meaning is not "lying" there on the picture, one has to make an effort to grasp it [6, p. 343].

The Pool "To observe and to spot" had for purpose to help students to realize the importance of sustained awareness, to introduce to a technique of visual scanning, and to understand the notion of "awareness efficiency" (ratio "time spent observing/amount of elements discovered").



Fig. 1. Exercise from the Pool "To observe and to spot". The picture (credit: ULg) came with the question: "How many animals do you see?"

The Pool “To compare and to measure” was shaped around selective awareness, systematic capture of differences, and relative dimensions of objects.

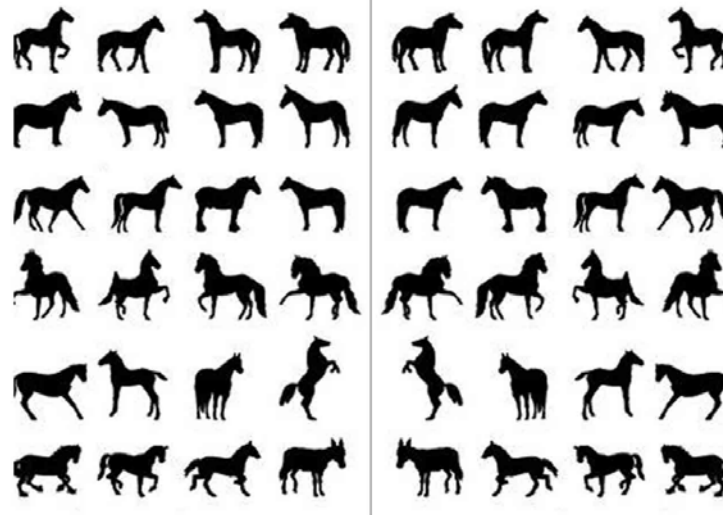


Fig. 2. Exercise from the Pool “To compare and to measure”. The picture (credit: Freepick) came with the assignment: “In the left frame, click on the horse that has no inverted twin in the right frame”.

The Pool “To observe in 3-dimension space” revolved around shape matching and mental construction of 3D objects from either sections of these objects or from 2D representations.

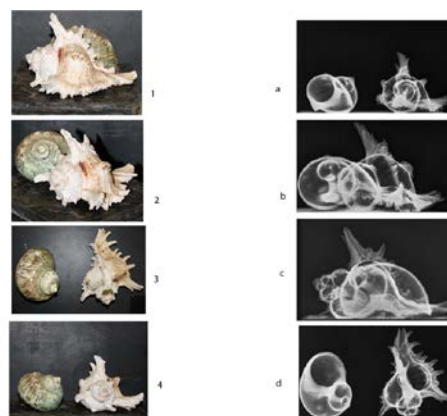


Fig. 3. Exercise from the Pool “To observe in 3-dimension space”. The picture (credit: ULg) came with the assignment: “Associate each view to its corresponding radiography”.

Two reflection amplifiers [7] were added to Pool A in view of prompting students' metacognitive introspection on their usual way to look and, in contrast, on the value of the visual scanning approach proposed (Fig. 1).

Comment avez-vous procédé pour balayer visuellement les images précédentes?

Question: 5 sur 11

☐ 1. balayage vertical

☐ 2. balayage vertical

☐ 3. balayage horizontal

☐ 4. balayage horizontal

☐ 5. balayage concentrique

☐ 6. balayage excentrique

☐ 7. balayage par petits cercles

☐ 8. balayage mixte

☐ 9. je ne sais pas

1. balayage vertical

2. balayage vertical

3. balayage horizontal

4. balayage horizontal

5. balayage concentrique

6. balayage concentrique

7. balayage par petits cercles

8. balayage mixte

9. je ne sais pas

Précédent

Suivant

Valider la réponse

Fig. 4. Structured reflective episodes questioned students on their spontaneous way of observing and on their possible improvement through visual scanning.

5 Feedback Questionnaire

A feedback questionnaire about the course was sent to the students. It comprised multiple choice questions coupled with open fields for written comments. It was filled in by 382 students, with the following results:

- 84% agreed or totally agreed that the exercises contributed to a reinforcement of their ability to analyze an image;
- respondents elaborated on the benefits: “I have learnt to go beyond what is the most visible in a picture” (50%), “I have learnt the technique of systematic approach (48%), “I have learnt that you can miss an image if you do not spot all important elements (44%);
- 80% were in favor of a module dedicated to digital imagery and based on the same principles;
- despite their appreciation of the “Learning to look” course, some students mentioned that it added workload to an already heavy curriculum;
- some students complained about the exercises for which missing only one image element out of many deprived of all the points.

6 Discussion and Future Work

Concern for the training of awareness is a long-standing issue. In 1942, the French philosopher S. Weil assimilated the major outcome of formal education to the development of attentional skills: “Although today this seems unknown, the training of the faculty of attention is the true goal and almost only value of all study. Most school exercises have a certain intrinsic value, but this is purely of secondary interest. All exercises which help to develop the power of attention are of interest, almost equally so. (...) Those who spend their formative years without developing this faculty of attending and directing mind to an object have missed a chief treasure” [8, p. 85]. Since then, other works [9, 10, 4] have stressed the importance of awareness (and germane notions).

Amongst possible objects of attention, pictures form a distinct category. Becoming visually literate is considered as an important endeavor for students, especially nowadays in veterinarian and medical education wherein static and dynamic digital imagery has gained momentum [11]. Indeed, at the same time, efforts are made to partly automatize recognition of terabytes of imaging data produced in many domains. But even the best algorithm-oriented processes does not discard human intervention and hybrid human-computer approaches of visual interpretation still appear as relevant [12]. Developing visual awareness remains therefore critical, not to mention its importance in new technological areas (augmented reality, quantified self, learning analytics, game-based learning, remote sensing imagery, etc. [13]) generating images that both burden and relieve attentional resources.

If eye can learn and must learn, the question of how to teach it is open [14, 15, 16]. The “Learning to Look” project offers a concrete, grounded in practice, and large-scale attempt to exert a competency which is seldom trained for itself, despite its paramount importance for future veterinary practitioners. This instructional setting, promoting a straightforward attention drill, must be further analyzed with regard to its relevance, efficacy conditions, and contribution to multimodal literacy development [17, 18, 19]. In this respect, a detailed assessment of gains in image handling, conveyed both by Module A as such and by the whole course (Module B - Describe an image and Module C - Interpret an image have been made available to students) is planned for the future.

Since the “Learning to Look” course is based on the assumption that awareness development can be stimulated through training from the general to the specific (from arbitrary to clinical images), instructors also plan to explore the possible use of the online course beyond veterinary sciences.

Based on students' positive reaction on this first run of the module, the instructors will ascertain the best schedule regarding the course release. Offering its content according to a distributed practice scheme [20, 21, p. 114] along the year – instead of a massed practice during a short period – could expand the benefits of the module and foster more sustainable learning. Technical options for an improved tracking of students' actions and scores will also be inspected.

References

1. Nakashima, R., Kobayashi, K., Maeda, E., Yoshikawa, T., Yokosawa, K.: Visual Search of Experts in Medical Image Reading: The Effect of Training, Target Prevalence, and Expert Knowledge. *Frontiers in Psychology* 4:166 (2013). doi: 10.3389/fpsyg.2013.00166
2. Snowden, P. T., Davies, I. R. L., Roling, P.: Perceptual learning of the detection of features in X-ray images: A functional role for improvements in adults' visual sensitivity? *Journal of Experimental Psychology: Human Perception and Performance* 26(1), 379-390 (2000). doi: 10.1037/0096-1523.26.1.379
3. Van der Gijp, A., Van der Schaaf, M. F., Van der Schaaf, I. C., Huige, J. C., Ravesloot, C. J., Van Schaik, J. P., Ten Cate, T. J.: Interpretation of radiological images: towards a framework of knowledge and skills. *Adv Health Sci Educ Theory Pract* 19(4), 565-580 (2014). doi: 10.1007/s10459-013-9488-y
4. Crawford, M.: *The world beyond your head. How to flourish in an age of distraction*. Viking, Great Britain (2015)
5. Steiner, J.: *Look-Alikes: The More You Look, the More You See!*. Little, Brown Books for Young Readers (2003)
6. Seale, C.: *Social research methods: a reader*. Routledge, New York (2004)
7. Verpoorten, D., Westera, W., Specht, M.: Reflection amplifiers in online courses: a classification framework. *Journal of Interactive Learning Research* 22(2), 167-190 (2011) <http://hdl.handle.net/2268/151374>
8. Weil, S.: *Réflexions sur le bon usage des études scolaires en vue de l'Amour de Dieu* [Reflections on the good use of scholastic studies in view of the Love of God]. In: Perrin, J.-M. (Ed.) *Attente de Dieu* [Waiting for God], pp. 85-96. Fayard, Paris (1966)
9. Endsley, M. R.: Theoretical Underpinnings of Situation Awareness: A Critical Review. In Endsley, M. R., Garland, D. J. (eds.) *Situation Awareness Analysis and Measurement*, pp. 3-29. Lawrence Erlbaum Associates, Mahwah, NJ & London (2000)
10. Salomon, G., Globerson, T.: Skill may not be enough: The role of mindfulness in learning and transfer. *International Journal of Educational Research* 2, 623-438 (1987)
11. Linsen, L., Hagen, H., Hamann, B., Hege, H.-C.: *Visualization in Medicine and Life Sciences II - Progress and New Challenges*. Springer-Verlag, Berlin, Heidelberg (2012)
12. Marée, R., Rollus, L., Louppe, G., Caubo, O., Rocks, N., Bekaert, S., Cataldo, D., Wehenkel, L.: A hybrid human-computer approach for large-scale image-based measurements using web services and machine learning. In: *Proceedings IEEE International Symposium on Biomedical Imaging*. IEEE (2014).
13. Johnson, L., Adams Becker, S., Estrada, V., Freeman, A.: *NMC Horizon Report: 2015 Higher Education Edition*. The New Media Consortium, Austin, Texas (2015)
14. Dev, P.: Imaging and visualization in medical education. *Computer Graphics and Applications* 19(3), 21-31 (1999). doi: 10.1109/38.761545

15. Petersson, H., Sinkvist, D., Wang, C., Smedby, Ö.: Web-based interactive 3D visualization as a tool for improved anatomy learning. *Anat Sci Ed* 2, 61-68 (2009). doi: 10.1002/ase.76
16. Silén, C., Wirell, S, Kvist, J, Nylander, E, Smedby, O.: Advanced 3D visualization in student-centred medical education. *Med Teach* 30(5), 115-24 (2008)
17. Jewitt, C., Kress, G. R.: *Multimodal literacy*. P. Lang, New York (2003)
18. Unsworth, L.: *Teaching multiliteracies across the curriculum*. Open University Press, Buckingham-Philadelphia (2001)
19. Schnotz, W., Baadte, C., Johnson, A., Mengelkamp, C.: Knowledge Acquisition from Verbal and Pictorial Information. In: M. J. Lawson, M.J., Kirby, J.R.(eds.) *The Quality of Learning*. Cambridge University Press, Cambridge (2012)
20. Rohrer, D., Pashler, H.: Recent research on human learning challenges conventional instructional strategies. *Educ. Res.* 38, 406-12 (2010)
21. Hattie, J., Yates., G.: *Visible learning and the science of how we learn*. Routledge, New York (2014)

Prompting users to facilitate support needs in collaborative reflection

Oliver Blunk, Michael Prilla

Ruhr University of Bochum, Germany
{oliver.blunk, michael.prilla}@rub.de

Abstract: Reflection and collaborative reflection are common activities at workplace, in which people alone or together with colleagues revisit experiences to learn for future situations. Often support needs arise during reflection and for example people get stuck and don't know how to continue. We propose to fill this gap with prompting as tool-supported scaffolding mechanism. Based on literature and our own previous work on reflections support this paper presents a concept using prompting to support different goals based on known support needs in tool-supported collaborative reflection. We show an initial implementation of a prototype and an approach how to evaluate it. This work contributes to the (AR)TEL community in that it provides a concrete approach for scaffolding in reflection support to be discussed at the workshop and in that it shows how prompting can be used and implemented in tools to evoke reflection.

Keywords: collaborative reflection, prompting, reflection support

1 Introduction

Reflection is a common and important activity at workplaces [1]. It includes three stages: returning to past experiences, reassessing them in the context of today's experience, and then deriving conclusions about how to behave in future [2]. Schön differentiated reflection-in-action from reflection-on-action [1], with the former describing reflection about things currently happening and the latter describing reflection about things which happened in the past [1].

However in daily work often problems arise which make collaborative reflection difficult for people and for example sometimes they don't know how to proceed and thus get stuck while reflecting [3]. Therefore facilitation of reflection is needed. This paper presents a concept using prompting to facilitate different aspects of collaborative reflection. The goal is to help users reflect in work place settings and to overcome barriers. After a related work section the concept will be laid out, followed by the implementation of a prototype alongside an approach on how to evaluate the concept.

2 Related work

This section presents work available on reflection (support) at work, including underlying theories, a reflection model and prompting as the concept used to support reflection in our work.

Individual and Collaborative Reflection

Reflection is mostly conceptualized as an individual, cognitive activity [1, 2, 4], which creates value by understanding own practice and improving it. There have always been voices on the social side of reflection [5] advocating the common practice of people to reflect together, but only recently research on reflection in groups has gained momentum [6, 7]. In this work the term collaborative reflection describes reflection in which multiple persons or groups of people are involved. It has been found that such reflection is common practice at many workplaces, and that it has the benefit of producing results which surpass the reflection results of individuals [8]. It should be noted, however, that collaborative reflection always includes individual reflection phases such as applying group results to one's own situation [9]. Also collaborative reflection needs extra support for communication processes [10] and reflecting together adds complexity to the process of reflection, as multiple perspectives and contributions need to be coordinated and aligned [5].

Conceptualizing Collaborative Reflection: Models

Supporting (collaborative) reflection needs an understanding and operationalization of reflection processes that enable the development and implementation of support. There are many models available, including the three-stage model by Boud [2] and the cyclic reflection model by Kolb [4], which are used by most work available on reflection. However, these models focus on individual reflection and do not include a perspective on (technology) support for reflection, which make them hard to apply for designing support for reflection in practice.

Krogstie, Prilla and Pammer [9] developed a cyclic model that includes both a perspective on tool support and individual and collaborative reflection aspects (the "Computer Supported Reflective Learning" (CSRL) model shown in Fig. 1). The model contains four different stages, each having a defined input and output and thus describing how the stages feed into each other. In addition it contains triggers for reflection, which represent situations in which the reflection cycle is started. Tools can use this model by connecting to the stages, phases and triggers in order to facilitate the process and to ensure that required information for each phase is available.

Besides the four stages the CSRL model contains several *phases*, which describe activities that can be helpful in each stage. For example the *Initiate Reflection* stage contains phases like *Set objective* and *Involve others* (no. 2 in Fig. 1), which suggest that it is helpful to think about the reflection session in advance and that tools need to support bringing people together. Furthermore, the model shows that each stage has specific inputs and outputs, which support transitions between the stages. For example

without *data* about the work no reflection session can be initiated (“a” in Fig. 1) and without explicit outcomes change is not possible (“c”). Emphasizing the iterative nature of reflection, each stage can spark a new *Initiate reflection* phase, for example if a session did not result in an outcome and the group needs another reflection session. Using the model thus can provide support for tool designers to understand the needs of support for reflection processes [9]. In the research presented here it was used for this purpose and serves as a basis for describing goals for reflection support.

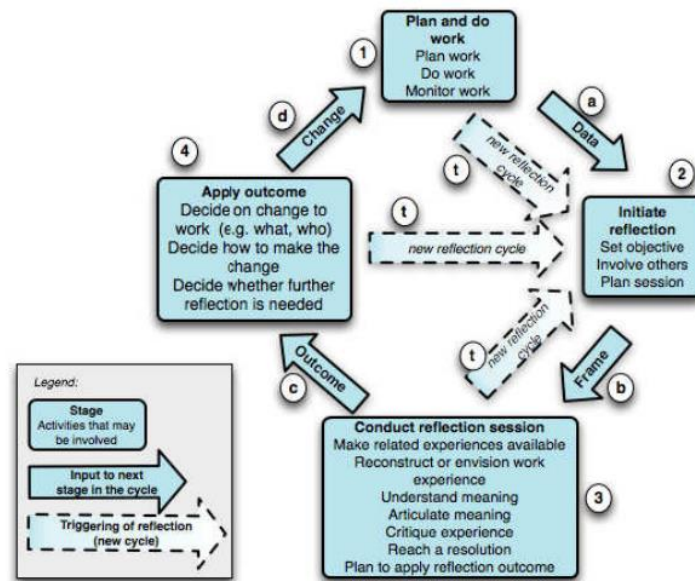


Fig. 1. The CSRL model by Krogstie, Prilla and Pammer [9]

Reflection Support: The need for scaffolding reflection at work

The application of reflection support at work faces many difficulties such as time and space available to reflect or continuity in reflection [9, 10]. Available work on diminishing these difficulties and supporting reflection at work can be differentiated into conceptual work describing means and strategies to support reflection, and work related to tools, which describes approaches to use tools to enable reflection.

On a conceptual level research often emphasizes the need for facilitation in reflection. Daudelin [5] emphasizes the need for moderation in reflection groups, Zhu [11] describes questions (for further information or to provoke further discussion) as important means to facilitate reflection, and van Woerkom and Croon [12] describe group cultures that include actions such as asking for feedback and questioning groupthink as supportive for reflection. Schön [1] points to the need for more awareness for reflection in daily work by suggesting the “reflective practitioner”, and Vince [13] emphasizes the need to establish reflective practice individually and in groups.

Concerning tools we found that there are several approaches, which describe different levels of tool support for various degrees of reflectivity of users. Tools often allow users to document their problems and challenges by either manually writing

down what happened [14] or capturing data about daily work [15, 16], which already helps structuring one's thoughts. More advanced tools such as ECHOES by Isaacs et al. [17] remind users to regularly return to such data, reflect on it and implement outcomes of their reflection in practice. Sharing documented issues, which allows people to engage with colleagues in collaborative reflection, is mostly done by sharing the tool used to document experiences with others in face-to-face settings. Online discussion forums widely used in other learning contexts [11] and other tools supporting groups [19] have been studied in the context of reflection only on a generic level.

In our work, in which we analyzed the behavior of four different groups using a tool facilitating threaded discussions for experience exchange at workplaces to support reflection [20, 21], we arrived at insights that support and extend the existing work discussed above. In a comparison between more and less effective reflection groups we found facilitation by group members (e.g., asking each other to contribute) and the provision of guidance in the reflection process to be helpful [21]. From an analysis of the content created in the tool we found that providing experiences rather than advice and describing emotions during experiences positively influences the creation of outcomes from reflection [20].

What can be taken away from the existing body of work on reflection support is that there is a need to *scaffold* (that is, guide, facilitate and structure) the process of reflection in order to enable individuals and groups to learn from and for their work.

Prompting as a means to scaffold Reflection

As described above there is a need for scaffolding in reflection processes to guide people in individual and collaborative reflection situations. Especially in real workplace situations additional problems arise while reflecting for example due to time restrictions or because workers are not trained in reflection. Among these problems, workers can get stuck or are not sure how to proceed, needing new impulses to continue [3]. Scaffolding can also help to overcome these barriers.

There are different means of scaffolding, including scripts [22] that guide users of tools through a step-by-step procedure of learning, ensuring that necessary steps are taken, and open learning environments providing awareness and notification to learners in order to show them possible helpful learning activities. It has been argued in learning research that neither of these ends provides a good solution for all learning processes, and that there is a need to carefully balance guidance and freedom in learning processes [23]. One means of scaffolding that creates this balance is *prompting*, which has been used in learning environments to facilitate tasks and to stimulate reflecting about those tasks [24, 25]. Prompts need to be differentiated from awareness mechanisms and notifications, which often don't have an instructional character [26].

Prompts are cues designed to stimulate a certain behavior of the recipient [27, 28], but they don't enforce that behavior [29], leaving the choice whether to react or not to the user. They can be created by oneself (self-prompting), by another person or a system (external-prompting) either randomly, periodically or trigger-based. Usually the person or system creating the prompt (prompter) sends a prompt to the recipient (promptee). Prompts may occur in the form of instructions given to the promptee [25]

or questions to be answered by the promptee [25], which fits the findings on using questions to stimulate reflection discussed above. From a technical point of view prompts are delivered by a prompting mechanism that may provide different prompts for different situations and purposes. Using a simple example, when setting an alarm clock (prompting mechanism) in the evening, one sets a prompt (the alarm itself) for oneself triggered by a matching time stamp, which most likely has the intention to instruct the user to get up in the morning. To help users with specific tasks it is helpful to have context-specific rather than abstract prompts [24].

As any scaffolding mechanism may also cause harm if not used in a proper way [23], prompts may also create negative effects. As an example for reminiscence longer prompts lead to lower response rates (but also elicit longer answers) [30]. They thus have to be designed carefully and the goal designing prompts is to achieve a tradeoff between the intensity of their usage and the effect on the user.

Related work has found that prompts are not always answered, which was dubbed negative in an education environment [31], in which prompts were part of the learning assignment. However, given the challenges reflection support faces at work, which often hinder people to reflect at all, we think that even if some prompts remain unanswered in certain cases, they are still helpful in creating opportunities for and scaffolding collaborative reflection at work, since we plan to *support* workers rather than enforcing the way they are using discussions at their workplace.

Although prompting has been used in the context of reflection as described above there is no concept for using prompts as scaffolding for various aspects of reflection in general. This paper presents such a concept, in which prompts help to facilitate reflection and assist if users are stuck while reflecting.

3 Concept to facilitate reflection through prompts

The following section shows our concept of how prompts can help facilitating (collaborative) reflection and how to overcome various barriers. For this we derived different goals from literature and our own work and connected each of the goals to the CSRL model presented above. We also present examples of prompts supporting those goals.

Goals for Reflection Support

Stage I: Plan and Do Work

In the initial stage of the CSRL cycle the main goal is to provide data to reflect upon.

G1 Document surprising experiences in daily work: Reflection is often caused by the discrepancy of reality in contrast how one expected something to happen [1]. Baumer calls this breakdowns, which are reasons to start reflecting [32]. Therefore, complementing means to capture data automatically, there is a need to document experiences in order to reflect about them later [10, 14]. Prompts for this goal are intended to start reflection and to help people develop a reflective view on their work.

Stage II: Initiate reflection

Reflection may end before it has started, meaning that discrepancies are not followed up or no insights are created. Initiating it includes setting objectives, involving others and supporting descriptions and initial reflections on the experiences shared.

G2 Set the objective: Boud et al. argue that reflection is not “and end in itself” and that it is focused towards a goal in order to change future behavior [2]. Therefore setting an objective allows for a more clearly structured reflection session. Prompts may help users to set an individual or group related objective that helps to guide the discussion. This is also part of the input for the next stage in the reflection cycle [9].

G3 Involve others: Involving others into problem-solving offers of getting feedback from others and finding solutions together [8, 10, 12]. Thus in line with recommendation research [33] there is an need to support reflection participants in inviting others such as people someone is frequently getting input from or people the user never worked with before to benefit from new ideas and insights [33]. Prompts can explicitly ask for such invitations and may include recommendations.

G4 Support individual reflection when describing experiences: Reflection participants should not only describe a problem but also include first explanations and justifications. Fleck and Fitzpatrick [15] as well as Hatton and Smith [34] describe this as two different levels with the first one as just descriptive but not being reflective. In order to move away from that level, prompts may guide people into reflection while starting a new discussion thread by asking to think of explanations and interpretations.

G5 Elicit problem description: Prompts can also help eliciting the problem description by asking for a more detailed description. Alternative explanations and different viewpoints are necessary to reach a form of dialogic reflection [15]. Additionally there might be also the need for prompts to limit the length of posts, since very long posts are often not read fully by others in contrast to very short posts which can't transport all required information [35]. This goal aims to help setting up the subsequent stage in the reflection cycle through trying to make sure that enough information is present.

Stage III: Conduct reflection session

A major aim of the reflection session is to create outcomes that people may use to improve their practices. This can be done in different ways:

G6 Get people to explicitly link to their experiences rather than giving plain advice: As described above we found that sharing experiences leads to an increased likelihood to get reflective outcomes in tool supported collaborative reflection [20]. Prompts may support this goal by asking people to argue from experience instead of giving just plain non-reflected advice. This also connects to the phase of making related experiences available in this stage of the CSRL model [9].

G7 Single Loop Learning & G8 Double Loop Learning [36]: Both goals support learning while reflecting [1, 2]. This may occur either on the level of learning for particular tasks or problems (single loop learning, see [36]) or by deriving more general insights in the nature and prerequisites of work (double loop learning). Prompts may guide reflection participants to either of these outcomes by asking for solutions to the particular problem or by focusing on supporting people to state what they can

learn in general respectively how the knowledge can be applied to different problems. This is also helpful for other people who are participating in the discussion thread.

Stage IV: Apply outcome

Most work on reflection does not include the implementation of insights. However, in order to provide effective support this stage is equally important as the other stages.

G9 Check whether stage has been reached: In order to proceed to the application of outcomes at least one outcome needs to be mentioned in the reflection session. Prompts may aim towards helping the author/starter of a discussion to identify outcomes or to start a new reflection cycle to e.g. pursue another direction in the discussion or discuss some point in detail. This and G10 are similarly supported by literature as G2 with these goals being more focusing on realizing the objective of the session.

G10 Plan application of reflection outcome: This goal supports user in transforming ideas from the reflection session into a detailed plan of how to implement the change. This way the outcome might get more concrete. This can help people engaging into multiple reflection cycles with describing a problem first, then reporting back insights and they have learned after that (see G11).

G11 Check application of outcomes of a previous reflection cycle: To support the implementation of change users can be reminded to regularly check their progress in applying outcomes from reflection [17]. Prompts may regularly ask users to self-assess their progress or ask them to revisit their goals.

Stage-independent (cross-cutting) goals

There are some goals that can be applied to multiple or even all stages of the CSRL model, including training on good reflection practice, support for self-efficacy and the provision of an environment in which reflection works.

G12 Train people how reflection works best: Reflection, though seemingly intuitive, is not easy but has to be learned. Explain to reflection participants how reflection processes work in order to enable them to proceed with reflection is common in some disciplines such as nursing, in which reflective practice is well established and studies explain that being reflective has to be trained [37]. Prompts may enable users to understand the basic concepts of reflection (based on the work of Schön [1] and Boud [2]) and they may provide concrete instructions how to proceed in order to show how collaborative reflection works (e.g., based on the CSRL model [9] discussed above). Though one challenge might be providing a way to deliver adequate personalized feedback regarding learner's success. Still the means of prompting itself has been used successfully in teaching and education to stimulate users elaborate their answers or to stimulate self-reflection [24, 25].

G13 Support people to feel safe in the environment: In discussion settings when people report of their challenges the fear of being judged or criticized can hinder people from posting [38]. Prompts for this goal include hints that one could post something anonymously thus avoiding direct criticism which seem to work in education settings [39], or try to remind people to treat each other fairly [40].

A prompting concept to implement the goals for reflection support

Table 1 shows an overview how the goals above can be implemented by concrete prompts. Each goal is connected to one or more example prompts.

Goal	Example prompts
G1: Document surprising experiences in daily work	What did surprise you in your daily work lately? Why?
	Have a look at your calendar of the last week. What was difficult for you? How?
G2: Set the objective	What is it you want to know from your colleagues? Ask them a specific question!
G3: Involve others	Who of your colleagues might help you in this? Mention him in your post to notify him or her (@username).
G4: Support individual reflection already in first post	What has happened? Is there already something you learned from it?
G5: Elicit problem description	Help your colleagues understand your problem: Try to describe what things you already tried to solve your issue!
G6: Explicitly link to experiences rather than giving plain advice	Suggestions are most helpful if they are based on your experience!
	What would you personally suggest as a solution? Why?
G7: Single Loop Learning	What have you learned regarding this topic so far from this discussion?
	What is your personal outcome of this discussion so far?
G8: Double Loop learning	What have you learned so far on an abstract level?
G9: Check whether stage has been reached	Do you have an idea from this discussion how to change your approach to the topic? If not, phrase a new question.
G10: Plan application of reflection outcome	How do you want to implement the suggestions of your colleagues?
G11: Check application of outcomes of a previous reflection cycle	Did your plan work? What are your experiences with the change? Tell your colleagues about it.
G12: Train people how reflection works best	What happened in that situation? How do you think about it now? How do you plan to handle similar situation in future?
G13: Support people to feel safe in the environment	You can also use the <i>post-anonymously</i> button if you think that you are judged.
	Don't only directly criticize your colleagues. Show them also what he/she did correctly

Table 1. Example prompts for each goal supporting collaborative reflection

State of this work and possible additions

As can be seen from the goals and corresponding prompts, currently the concept is focused on common problems concerning reflection, and it covers the whole cycle of

reflection as described in [9]. While the goals as well as the prompts may be extended, to the knowledge of the authors this is the only concept that shows how prompting may influence reflection in such a broad way. However, there are several possibilities in extending the concept to pursue facilitate other reflection related aspects:

Linking to creativity support: The concept may be complemented by creativity techniques in order to help users getting new ideas about how to approach their work related challenges and how to merge ideas into solutions. One creativity technique to support this might be directed brainstorming [41], in which a topic is split up into individual parts having a brainstorming each. For the reflection participants this adds the benefit of choosing from a number of ideas, which is easier than creating new ones [42]. Santanen et al. also used the means of prompting in their study of directed brainstorming [41], thus linking this to reflection might be promising, but further research is required to study how the concept of directed brainstorming through prompts is also helpful in reflection settings.

Setting goals: Setting personal goals is beneficial for personal reflection since people can use this to plan reflection topics or sessions [43]. This is also an opportunity to facilitate reflection through the means of prompting. Prompts could help users in reminding them of looking at their goals to reassess whether the goal has already been met, whether the goal is still worth pursuing or whether the goal is now obsolete. Also prompts can assist users in checking whether discussion contributions are helpful to progress towards their goal.

Sustaining reflectivity: Often people who are more experienced in their role are less likely to have a reflective approach to their work [1, 44]. Prompts may evoke and sustain their reflexivity by helping these people to take a role similar to a mentor in which they can contribute with their experience on topics initiated by colleagues. Mentorships often have various benefits also for the mentor like learning from the protégé, getting new work related information, and extending the network [45]. The approach is to deliver prompts which are not asking the experienced worker directly to think about their work, but to try get their feedback for the work of their mentees, which in turn might possibly cause them to think about their work.

4 Implementation and Evaluation: Work in Progress

This section reports on the implementation of a prototype incorporating the aforementioned prompting concept, including an approach for its evaluation.

Implementation

To evaluate the concept we are currently implementing a system supporting reflection in online discussion threads as used in typical tools such as community platforms and learning environments. This enables a group of people working together to talk together about the problems they face in an asynchronous way, not requiring them to find a common time and date [10] and to exchange experiences with colleagues working in the same organization but in different offices. Using prompts might then facili-

tate collaborative reflection and discussion among the participants in the group. This is especially helpful if used in existing platforms in an organization, as it adds reflection to the platform while preserving a well-known and accepted tool for users¹.

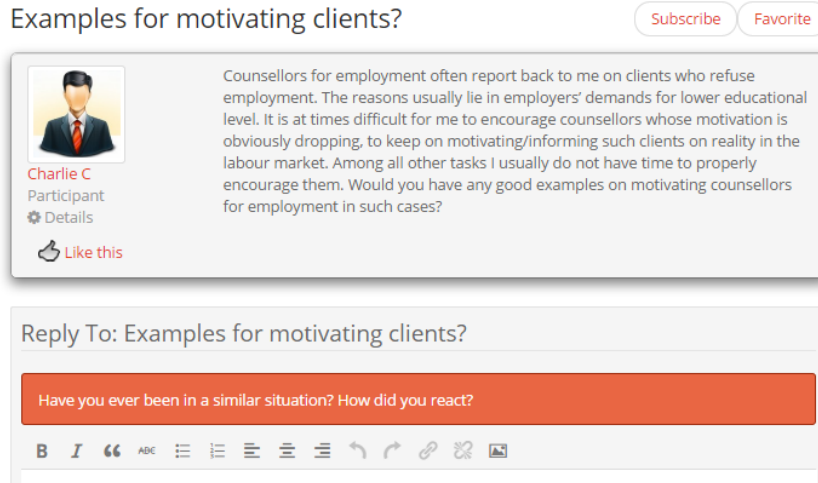


Fig. 2. Prototype to evaluate the prompting concept

The prototype currently features threaded discussions as well as social networking features like profiles, personal messages, friendships, mentioning. It also contains the option to share files and a common news section. Features like mentioning facilitate involving others (G3), making adhering to that type of prompts more simple. Having friendships allows people to expand their network to get automatically get notified of discussions their colleagues participated in.

Fig. 2 depicts a discussion thread in the prototype, showing that a thread was already started and that the user viewing the thread has now the possibility to reply. Just below the thread and above the text input area the prompt is shown asking the recipients to think back whether they also experienced something like this and to tell their experiences (G6). This also shows that the prompts are implemented in a way not forcing the recipients to react in any specific way. The prompts will be later on accompanied by a button containing information that the prompt is trying to help them structuring their posts and thus showing a trajectory of how they can make use of it.

Ideas for the Evaluation of the Prompting Approach

The concept described in this paper will be evaluated with groups of 10-100 users as part of the European project EmployID working as counsellors in public employment services. The platform is intended to support the exchange of experiences among practitioners and offering an environment for reflection. While the evaluation will

¹ The mechanism for adding the prompts to existing platforms will be described in the ECTEL 2015 poster session, see [46],

begin late in 2015 we already compiled a list of criteria we plan to use to evaluate whether and to what extent the concept is facilitating collaborative reflection:

- **Do the prompts change the behavior of the participants?** If prompts are successful we should be able to see more activity related to reflection (e.g., more experiences shared or questions asked).
- **Does more reflection occur in the discussion threads?** If the prompts facilitate reflection we should be able to see qualitative and quantitative changes in the reflection outcomes (e.g., more outcomes documented and more satisfaction with the outcomes among participants).
- **Which prompts help facilitating reflection the most?** While our concept is based on thorough literature analysis and previous work it is likely that some prompts are more or less helpful than others. Comparing the outcomes of the two questions mentioned above with the prompt being used may therefore create valuable insights on how to prompt for reflection.
- **Are there any long-term learning effects following the display of prompts?** Prompts should not only guide activity but also help people to become more reflective. If this is successful we should be able to see the changes measures in the first two questions even if we reduce the amount of prompts provided to users. This is also related to using prompts as a scaffold which is reduced bit by bit over time when the learner doesn't need the scaffold anymore.

In order to answer the questions an evaluation setting with a within-groups design is planned, which includes having two groups in a counter-balanced design. This way one group gets prompts for a certain time and no prompts after that, and the other group starts without getting prompts and then switches to getting prompts. This design has the advantage that the size of the group of participants can be smaller since everybody gets prompts at one point of time. A disadvantage might be that having prompts at first influences the behavior in a long-term way, affecting the time period when said group does not receive prompts anymore. However, this disadvantage could be also used to answer the last question regarding long-term effects of prompts shown to users.

To answer the questions we plan to evaluate the concept on two different levels. The first level is whether the prompts are influencing the content of the discussion, that is, whether the users make use of the suggestions, for example whether displaying a prompt asking to evaluate colleagues did leads to more users mentioned in the posts. The second level involves checking whether those interventions also lead to more reflection outcomes in terms of whether the post indicated that the user either learned something or indicated that the user intends to do something differently in future.

Prompts and reactions to it could be evaluated through a content analysis as demonstrated in [20]. This may give insights whether the content of written discussions may be influenced by the prompt or not. Prilla et al. recently published a coding scheme for analyzing reflection content [20], which allows for checking whether the content shows indication that the users learned something or intends to do something differently in future. Content analysis is also an evaluation strategy previously employed to analyze prompts [24, 47]. Methods like pre- and post-tests on the content like in education settings [25] may not be feasible in workplace settings. Answering

the question whether a user actually saw and respectively read the prompt could be either answered statistically [25] or in pre-tests technology-supported e.g. with eye-tracking. However eye-tracking doesn't seem feasible in a larger workplace setting. Further work has to be done to make sure that this case is considered in the evaluation.

Prompts trying to evoke a more elaborated answer could also be evaluated on a quantitative level. Measuring the amount of words in the corresponding discussion contributions could give a basic insight, whether people adhered to the prompt. Additionally content coding can assess whether contributions contain more descriptive content about problems or approaches the author already tried to solve the problem.

Prompts aiming to guide users can be also evaluated through content analysis by checking whether the text contains elements the prompt asked for. In order to evaluate whether prompts targeting the involvement of colleagues are successful, a social network analysis may be useful to track changes in the personal network of people reflecting together in online threaded discussions. Prompts suggesting that content could be posted anonymously can also be evaluated without content analysis but only with the information how often the prompt was displayed and how often the feature was used respectively how often the feature was used after the user has seen the prompt once.

5 Conclusion and Outlook

We presented a concept based on using prompts to facilitate tool supported collaborative reflection and to support certain reflective behavior. We based the approach on literature analysis and our own previous studies, and we chose this approach because we think it is most suitable to cover a broad bandwidth of support for reflection.

The main contribution of this paper is the presented concept of goals supported by prompting to facilitate collaborative reflection – to the knowledge of the authors there is no other concept linking prompts to reflection support in such an extent. Additionally the paper already shows a first implementation of a prototype outlining how the concept can be used in a setting with online thread discussion forums. Our work is still in progress, and we think it provides fertile grounds for discussion in the ARTEL workshop.

In future work we plan to evaluate the concept with the presented prototype in a workplace setting. We already presented a rough evaluation concept in the paper which shows how we plan to evaluate whether and how different prompts are feasible for collaborative reflection support in a workplace setting.

Acknowledgements

This work is part of the EmployID (<http://employid.eu>) project on “Scalable & cost-effective facilitation of professional identity transformation in public employment services” supported by the EC in FP 7 (project no. 619619). We thank all colleagues and associated partners for their cooperation and our fruitful discussions.

References

1. Schön, D.A.: The Reflective Practitioner: How Professionals Think in Action. Basic Books (1983).
2. Boud, D., Keogh, R., Walker, D.: Reflection: Turning Experience Into Learning. Routledge (1985).
3. Prilla, M.: Collaborative Reflection Support at Work: A Socio-Technical Design Task. ECIS 2014 Proceedings. (2014).
4. Kolb, D.A.: Experiential learning: Experience as the source of learning and development. Prentice-Hall Englewood Cliffs, New Jersey (1984).
5. Daudelin, M.W.: Learning from experience through reflection. *Organizational Dynamics*. 24, 36–48 (1996).
6. Baumer, E.P., Khovanskaya, V., Matthews, M., Reynolds, L., Sosik, V.S., Gay, G.K.: Reviewing Reflection: On the Use of Reflection in Interactive System Design. In: Proceedings of DIS 2014 (2014).
7. Marcu, G., Dey, A.K., Kiesler, S.: Designing for Collaborative Reflection. In: Proceedings of PervasiveHealth'14 (2014).
8. Hoyrup, S.: Reflection as a core process in organisational learning. *Journal of Workplace Learning*. 16, 442–454 (2004).
9. Krogstie, B.R., Prilla, M., Pammer, V.: Understanding and Supporting Reflective Learning Processes in the Workplace: The CSRL Model. In: Hernández-Leo, D., Ley, T., Klamma, R., and Harrer, A. (eds.) *Scaling up Learning for Sustained Impact*. pp. 151–164. Springer Berlin Heidelberg (2013).
10. Prilla, M., Pammer, V., Krogstie, B.: Fostering Collaborative Redesign of Work Practice: Challenges for Tools Supporting Reflection at Work. In: Proceedings of the European Conference on Computer Supported Cooperative Work (ECSCW 2013) (2013).
11. Zhu, E.: Meaning Negotiation, Knowledge Construction, and Mentoring in a Distance Learning Course. (1996).
12. Van Woerkom, M., Croon, M.: Operationalising critically reflective work behaviour. *Personnel Review*. 37, 317–331 (2008).
13. Vince, R.: Organizing reflection. *Management Learning*. 33, 63–78 (2002).
14. Scott, S.G.: Enhancing Reflection Skills Through Learning Portfolios: An Empirical Test. *Journal of Management Education*. 34, 430–457 (2010).
15. Fleck, R., Fitzpatrick, G.: Reflecting on Reflection: Framing a Design Landscape. In: Proceedings of the 22Nd Conference of the Computer-Human Interaction Special Interest Group of Australia on Computer-Human Interaction. pp. 216–223. ACM, New York, NY, USA (2010).
16. Pammer, V., Knipfer, K., Krogstie, B., Wessel, D., Prilla, M., Lindstaedt, S.: Reflective Learning at Work - A Position and Discussion Paper. In: Proceedings of 1st European Workshop on Awareness and Reflection in Learning Networks (ARNets11) at EC-TEL 2011 (2011).
17. Isaacs, E., Konrad, A., Walendowski, A., Lennig, T., Hollis, V., Whittaker, S.: Echoes from the past: how technology mediated reflection improves well-being.

- In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp. 1071–1080. ACM, Paris, France (2013).
18. Prilla, M.: User and Group Behavior in Computer Support for Collaborative Reflection in Practice: An Explorative Data Analysis. In: Rossitto, C., Cioffi, L., Martin, D., and Conein, B. (eds.) COOP 2014 - Proceedings of the 11th International Conference on the Design of Cooperative Systems. Springer (2014).
 19. Lee, S.: Design and analysis of reflection-supporting tools in computer-supported collaborative learning. *International Journal of Instructional Technology and Distance Learning*. 2, 49–56 (2005).
 20. Prilla, M., Nolte, A., Blunk, O., Liedtke, D., Renner, B.: Analyzing Collaborative Reflection Support: A Content Analysis Approach. In: Proceedings of the European Conference on Computer Supported Cooperative Work (ECSCW 2015) (2015).
 21. Prilla, M.: Supporting Collaborative Reflection at Work: A socio-technical Analysis. *AIS Transactions of Human-Computer Interaction*. (2015).
 22. Kobbe, L., Weinberger, A., Dillenbourg, P., Harrer, A., Härmäläinen, R., Häkinen, P., Fischer, F.: Specifying computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning*. 2, 211–224 (2007).
 23. Dillenbourg, P., Järvelä, S., Fischer, F.: The evolution of research on computer-supported collaborative learning. In: *Technology-enhanced learning*. pp. 3–19. Springer (2009).
 24. Davis, E.A., Linn, M.C.: Scaffolding students’ knowledge integration: prompts for reflection in KIE. *International Journal of Science Education*. 22, 819–837 (2000).
 25. Thillmann, H., Künsting, J., Wirth, J., Leutner, D.: Is it Merely a Question of “What” to Prompt or Also “When” to Prompt?: The Role of Point of Presentation Time of Prompts in Self-Regulated Learning. *Zeitschrift für Pädagogische Psychologie*. 23, 105–115 (2009).
 26. Palanque, P., Winckler, M., Martinie, C.: A Formal Model-Based Approach for Designing Interruptions-Tolerant Advanced User Interfaces. In: Hussmann, H., Meixner, G., and Zuehlke, D. (eds.) *Model-Driven Development of Advanced User Interfaces*. pp. 143–169. Springer Berlin Heidelberg (2011).
 27. Stichter, J.P., Lewis, T.J., Whittaker, T.A., Richter, M., Johnson, N.W., Trussell, R.P.: Assessing Teacher Use of Opportunities to Respond and Effective Classroom Management Strategies Comparisons Among High- and Low-Risk Elementary Schools. *Journal of Positive Behavior Interventions*. 11, 68–81 (2009).
 28. McKenzie-Mohr, D.: Fostering sustainable behavior through community-based social marketing. *American Psychologist*. 55, 531–537 (2000).
 29. Fivush, R., Gray, J.T., Fromhoff, F.A.: Two-year-old talk about the past. *Cognitive Development*. 2, 393–409 (1987).
 30. Peesapati, S.T., Schwanda, V., Schultz, J., Lepage, M., Jeong, S., Cosley, D.: Pensieve: Supporting Everyday Reminiscence. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp. 2027–2036. ACM, New York, NY, USA (2010).

31. Greene, B.A., Land, S.M.: A Qualitative Analysis of Scaffolding Use in a Resource-Based Learning Environment Involving the World Wide Web. *Journal of Educational Computing Research*. 23, 151–179 (2000).
32. Baumer, E.P.: Reflective Informatics: Conceptual Dimensions for Designing Technologies of Reflection. In: *Proceedings of CHI 2015* (2015).
33. Manouselis, N., Drachsler, H., Verbert, K., Duval, E.: *Recommender Systems for Learning*. Springer Science & Business Media (2012).
34. Hatton, N., Smith, D.: *Facilitating Reflection: Issues and Research*. (1994).
35. Wise, A.F., Zhao, Y., Hausknecht, S.N.: Learning Analytics for Online Discussions: A Pedagogical Model for Intervention with Embedded and Extracted Analytics. In: *Proceedings of the Third International Conference on Learning Analytics and Knowledge*. pp. 48–56. ACM, New York, NY, USA (2013).
36. Argyris, C., Schön, D.A.: *Organizational learning II: Theory, method, and practice*. Addison-Wesley (1996).
37. Ruth-Sahd, L.A.: Reflective practice: a critical analysis of data-based studies and implications for nursing education. *J Nurs Educ*. 42, 488–497 (2003).
38. Platzer, H., Blake, D., Ashford, D.: Barriers to learning from reflection: a study of the use of groupwork with post-registration nurses. *Journal of Advanced Nursing*. 31, 1001–1008 (2000).
39. Tan, N.Y.L., Chen, W., Looi, C.-K.: GroupScribbles as a rapid CSCL tool: Learning experiences of pre-service teachers. Presented at the (2009).
40. Kottkamp, R.B.: Means for Facilitating Reflection. *Education and Urban Society*. 22, 182–203 (1990).
41. Santanen, E.L., Briggs, R.O., de Vreede, G.: The cognitive network model of creativity: a new causal model of creativity and a new brainstorming technique. In: *Proceedings of the 33rd Annual Hawaii International Conference on System Sciences*, 2000. p. 10 pp. vol.1– (2000).
42. MacCrimmon, K.R., Wagner, C.: Stimulating Ideas through Creative Software. *Management Science*. 40, 1514–1532 (1994).
43. McAlpine, L., Weston, C., Beauchamp, C., Wiseman, C., Beauchamp, J.: Building a metacognitive model of reflection. *Higher Education*. 37, 105–131 (1999).
44. Mamede, S., Schmidt, H.G.: Correlates of Reflective Practice in Medicine. *Adv Health Sci Educ Theory Pract*. 10, 327–337 (2005).
45. Ragins, B.R., Scandura, T.A.: Burden or blessing? Expected costs and benefits of being a mentor. *Journal of Organizational Behavior*. 20, 493–509 (1999).
46. Prilla, M., Blunk, O.: Reflective TEL: Augmenting Learning Tools with Reflection Support. In: *Proceedings of the Tenth European Conference on Technology Enhanced Learning*. Springer (2015).
47. Rosenshine, B., Meister, C., Chapman, S.: Teaching Students to Generate Questions: A Review of the Intervention Studies. *REVIEW OF EDUCATIONAL RESEARCH*. 66, 181–221 (1996).

A course concept for enhancing reflective learning - bringing research project results into the field

Nils Faltin, Margret Jung

IMC information multimedia communication AG, Saarbrücken, Germany
{nils.faltin, margret.jung}@im-c.de

Abstract. After a successful evaluation at the IMC in the project MIRROR to enhance reflective learning by coaching and usage of two apps developed in the project, the instructional design was further developed. Below three phases are described that show the development from a research prototype to a commercial blended learning course. The first phase was a summative evaluation. Ten staff members took part in a time management coaching at our company IMC. In the second phase a time management open online-course was created. There the participants were offered to use two apps from the MIRROR project and tele-coaching for a fee. In the third phase a blended learning course was created and evaluated with three human resource managers. It included the two mentioned apps and individual coaching sessions and group sessions. The human resource managers were satisfied with the concept. The course was then included in the internal training catalogue and is currently running.

Keywords: survey· time management mooc· time management course· blended learning· Activity Recommendation App – ARA· computer activity tracking tool· soft skills improvement· experiences· personal coaching· group sessions· new concept· reflective learning· survey· project MIRROR· trigger· implementation of reflection outcomes· Manic Time· KnowSelf

1 Introduction

Reflection on work experiences can lead to new insights and ideas how to handle work situations better in the future. But the capturing of experiences during work and the reflection on this data is only a part of a more comprehensive offering needed for a successful improvement. The other part is the creation of a viable reflection outcome and the validation of this outcome when it is applied in practice (see [1]). Based on this validation, a change can be approved, reverted, or improved and validated again.

Whilst several applications support users to capture data during work in order to provide it in a subsequent reflection session, the later parts of the reflection cycle is often left unsupported. To also cover this part, we created a concept to support people to learn how to improve by reflective learning. One part of this concept is the Activity Recommendation App (ARA) that was created in the MIRROR project (see [2]). The app allows capturing personal experiences relating to recommendations defined in individual

or collaborative reflection sessions and viewing other members' experiences if a recommendation targets a team. ARA supports the evaluation of a recommendations' usefulness when applied in practice, in order to enable its improvement and support the decision to declare it as learned or to suspend its use.

Another part of the concept is a computer activity tracking app that records the computer usage in a time management scenario. While analysing the recorded data, reflection is triggered and the user is supported in reviewing the personal learning progress. These two apps had the aim to support reflective learning in our different concepts of time management scenarios. But another part was also very important. We wanted to support the participants in using the apps, in reflecting on recorded data and in implementing time management rules.

2 First phase

A summative evaluation took place at our company IMC over a period of six weeks (see [3]). Ten staff members took part in a time management coaching. The approach combined the usage of a computer activity tracking tool and the Activity Recommendation App with a weekly coaching session. Five participants used the time tracking tool KnowSelf that was created in the MIRROR project and the other five staff members used the commercial tool ManicTime (see [4]).

In the weekly coaching sessions the coach and the coachee reviewed the individual progress, adjusted the time management rules if not appropriate anymore, or, when the particular goal has been achieved and the new behavior has been adopted, decided that no further practice regarding that goal is needed. ARA served well as a support for learning time management by providing a data basis for the coaching sessions. It was used by coach and coachee to set time management goals and to document and monitor the progress in learning new time management techniques. Both benefited from the better preparation for the coaching sessions available with the notes in ARA. Furthermore, the app helped the coachees to focus their goals.

After the evaluation, the coach and several coachees suggested to improve the instructional design of future trainings by forming peer groups to train time management techniques. This would allow participants to benefit from sharing experience data to compare own progress with that of others and learn from each other's experiences.

The study showed that coaching is a good instructional setting to support reflective learning. The coaching approach has increased the reflection in the workplace and coaching serves as a trigger for reflection. People need support in reflective learning. Technical applications as tracking apps or ARA are important, but even here the people often need a guidance of a coach.

3 Second phase – time management MOOC

Based on the insights from the MIRROR project study, IMC has created a free online course for time management that includes usage of the ARA and KnowSelf (see [5]).

The MOOC includes videos, scripts, self-tests, screencasts and examples of time management rules that learners can create in ARA. In addition to these free elements, learners can opt for a human tele-coach who can be booked for a fee.

The purpose and use of ARA and KnowSelf is explained in the course with an example scenario. It shows how an office worker uses both applications to improve his time management. In addition, the usage of both applications is explained in several short screencasts.

This MOOC attracted 1000 registered participants in just three months and has now, after one year reached 1600 registered participants.

It turned out there was very little usage of the ARA and KnowSelf (measured by downloads and app registrations). A reason could be that the added value is not visible for learners and their personal use. Another reason could be the complexity of the apps and the related effort at first sight.

In addition, there were only very few requests for tele-coaching. A reason could be that participants of a free MOOC course do not expect to pay for additional services and the cost of coaching is relatively high for a personal budget.

As it is difficult to study MOOC usage in detail and to watch interview individual MOOC participants a new offer was created that is easier to evaluate and optimize.

This resulted in a third phase.

4 Third phase – blended learning format

4.1 The concept

Participants of the first study had suggested to form peer groups that work on a common issue. To provide learners with an opportunity to exchange experiences on similar problems we formed a group and a regular meeting. We carried out a time management course with three human resources managers of two companies who had a dual role: participants of the course and at the same time evaluators of our new concept. They should find out if this type of approach is a possible and good program for employees of their company. That should help us to gain further insights into improving our approach.

The concept was a blended learning approach with coaching to enhance reflective learning and to promote a successful transfer of theory into practice. The course consisted of three parts: online course, individual coaching sessions and group sessions. Part of the concept was also ARA and Manic Time. We chose ManicTime because it received better evaluations in comparison to KnowSelf in the first phase (see [3]).

All these parts are intended as a reflection trigger, they shall support the implementation of solutions and finally support the participants in various ways during reflective learning.

4.2 Reflection triggers and reflective learning supports

Online-Course. The time management learning content is only opened for the current participants. There are topic sections that are released week after week. The course

includes videos, scripts, self-tests, screencasts, apps, exercises and summaries of the group sessions. The participants are able to discuss directly in the portal. Working with the learning content, the participants begin to reflect on their own situation and their personal time management. The idea is that they have already thought about the content before they meet the coach or other participants.

Individual and group sessions. In the weekly one-hour individual coaching sessions the current learning content is discussed, reflected and aligned with the individual situation of the participant together with the coach. They analyze data from the tracking app and discuss the notes in ARA. The coach asks why the recommendation has a certain rating and how it can be improved.

In the weekly one-hour group sessions the participants have the possibility to exchange experiences and to discuss the learning content. They can further discuss exercises in the learning portal as well as the ARA recommendations. Reflection is triggered here by discussions. The participants can propose solutions to each other and motivate each other to follow their goals.

ManicTime and Activity Recommendation App. ManicTime can trigger reflection when the user starts to analyze the recorded data. Problems – e.g. spending too much time for unnecessary tasks at work – can be defined. It also supports the user in observing and controlling solution implementation and behavior changes.

ARA supports reflective learning by enabling the participants to define problems and solutions. Such solutions are recommendations that the participants have to evaluate for a certain period of time. Step by step they change their behavior by following the recommendations.

4.3 Results

In the last group session the coach wanted the participants to discuss their opinions and experiences. The Coach asked them some questions about how they like the course concept, about the named and reported risks and opportunities at the beginning of the course and about their priorities of the course parts. The statements were reported by the coach.

All in all the human resource managers were very satisfied with the course format. They liked the blended learning approach. The advantage is that a participant learns by watching videos, reading the scripts and doing homework. In this way, he has already collected experiences before having an individual coaching session. So he can discuss problems, ideas and goals concerning the new topic section.

The concept was created with several parts and the intention that all these parts trigger reflection and support reflective learning. We expected that the participants could learn independently while being supported by every part of the concept. After the 12 weeks with the three human resource managers we discussed the results in a group session. They evaluated the concept in their dual role: as participants and then as human resource managers. They provided improvement proposals, said they were convinced of

the potential of this instructional approach and asked to provide this as a regular course for the employees.

Risks and opportunities. One of the named risks was work overload (by course tasks adding to the work load of regular work tasks). After the course the group agreed that this became a problem in the Christmas season. This is in line with our findings from the first phase: When participants are very busy, they want to see benefits as soon as possible. But changes in time management practice based on reflective learning need time to unfold and pay off. That is why participants often become unsatisfied during busy periods although this is exactly the time in which the most participants would like to see improvement. Other risks like breach of trust (confidential information leaking out of the group) or frustration (because of reflection leading to realizing problems that cannot be solved) did luckily not materialize.

The hoped-for transfer support of theoretical content into practice took place. The participants confirmed that compared with other conventional trainings this concept really helped them to learn better. The new aspect was that they could combine theory and personal situations and practical experiences. They had time to practice exercises, make experiences and discuss about individual problems and solutions in this course. Behavior changes took place too. This can be seen as the major advantage in effectiveness of supported reflective learning in comparison to conventional trainings.

Furthermore, the awareness of personal time management was increased and the participants optimized their work behavior. They even confirmed a reduction of stress.

Priorities. Finally, in the group discussion the participants were asked to prioritize the concept parts regarding their personal improvement (see Fig. 1). Here, 1 is the highest and 5 is the lowest priority.

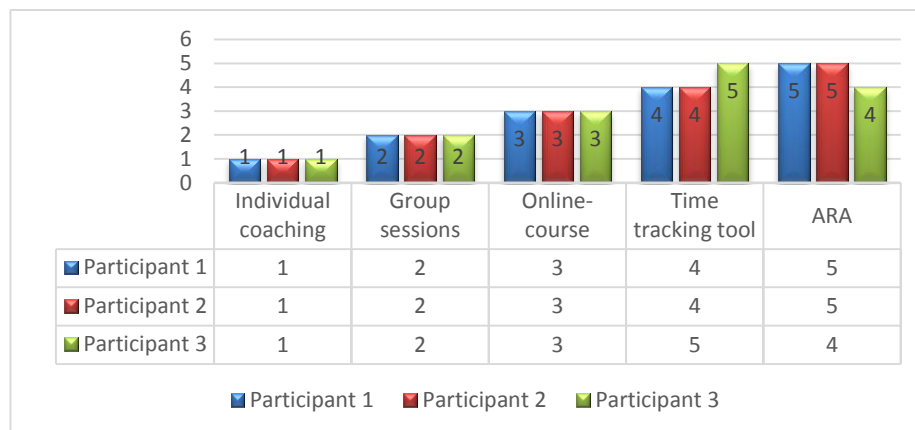


Fig. 1. Concept parts sorted by priority (1 highest, 5 lowest priority)

It is clearly evident that the individual coaching was the most important for the participants. The reason is that they got suggestions for the practical implementation of the tasks in the individual coaching. They also had a healthy pressure to invest time and

energy into their learning as they knew that the coach would observe and ask about personal learning processes. In addition, their personal situation has always been subject and there was space to talk about frustration, but also to find solutions.

On the second place are the group sessions. The experience exchange was important for the participants. One participant emphasized, for example, that it helped him to continue with the course content when he has seen how far the other participants are and that they share experiences. A participant complained that it was spoken too much about the course concept in the group sessions. That was because of their second role as concept evaluators. In addition, it was noted that the group sessions should take place less frequently, less than one time per week because there was not enough time between individual and group sessions. In this time the participant cannot make many experiences. Then they often discussed issues with other participants that were already discussed with the coach a short while ago.

The general content of the online course was ranked third. The theory and the exercises contained in the online course provided some basic knowledge. With new methods and time management techniques, the participants were able to improve their time management.

Overall, ManicTime and ARA were regarded as the least important parts. The human resource managers did not see them as essential for their personal progress. Nevertheless, they saw benefits in using the apps. ManicTime can be used to measure work time spent on certain tasks which can for example be used as basis for discussions with the supervisor about too high work load. This is an example of an organizational level problem rather than a personal time management problem that needs to be solved on the organizational level.

ARA was good for documenting experiences and to observe the own learning progress. But as the experiences were discussed in the individual coaching sessions, only the documentation part of reflective learning was supported in this scenario, and ARA had the least benefit in comparison to the other parts of the concept. We created an ARA widget in the course portal to facilitate the use. There the participants were able to directly and quickly document and share experiences, without having to log in separately in ARA. Still the widget was not used by participants as their need for sharing was already covered by the regular group presence sessions.

Proposals for future course runs. The participants were satisfied with the course and saw a high potential in it. As human resource managers, they encouraged us to offer the course with some changes in the internal training catalog. With the support of one of the human resource managers we created an offering for employees.

The participants also suggested a stronger guidance by the coach in the group sessions. In addition, the group sessions should not only function for experience exchanges, but also as training sessions with short exercises. After these exercises the participants could discuss the results.

5 Current phase

Since May the instance of the course as an official training offering of the companies group is ongoing. The concept is similar to the course with the human resource managers. There is an online-course with ARA and ManicTime and individual as well as group sessions. While number of group sessions and coaching sessions remain roughly the same, the course duration was extended from six to twelve weeks to reduce the weekly work load of the participants.

At the moment, four employees participate in the course. The participants come from two different companies. The presence sessions take place in one building in Saarbrücken. One participant works in another city far away and therefore he gets tele-coaching (and some extra coaching sessions as he cannot participate in the group sessions). He exchanges experiences with the other participants in the course portal, thanks to the ARA widget.

This is a 12-weeks-long course again. But now the individual and group sessions take place alternatively every two weeks. Participants can opt for individual coaching sessions to take place more frequently and for a shorter duration in consultation with the coach.

6 Outlook

We have learned that the concept works. It supports people in the process of reflective learning. All parts of the concept function as triggers for reflection and together they help participants to implement the reflection outcomes into practice.

We are interested in a continuing development and monitoring of reflective learning based on this concept. We have experienced that awareness and reflection technology together with personal coaching help employees to change work practice.

Therefore, we are currently planning more courses and studies based on this concept. We experienced that apps can serve as reflection triggers and can support people in reflective learning. But most often nontechnical parts, e.g. human support in a time management course has the best evaluation results. Our aim is to increase the focus on the applications in future studies and to find out the reason why this is so.

References

1. Krogstie, Birgit, Michael Prilla, and Viktoria Pammer: "Understanding and Supporting Reflective Learning Processes in the Workplace: The RL@Work Model." In *Proceedings of the Eighth European Conference on Technology Enhanced Learning (EC-TEL 2013)*, 2013.
2. MIRROR project for reflective learning at work, <http://mirror-project.eu/>
3. Bratić, Marina (KNOW): "The IMC Evaluation of the KnowSelf and ARA App (part of the Time Management Coaching Approach)", Graz (2014)
4. ManicTime: <http://www.manictime.com/>
5. MOOC "Time Management" (German) on OpenCourseWorld, <http://bit.ly/1ufnS0v>

Feeler: supporting awareness and reflection about learning through EEG data

Eva Durall¹, Teemu Leinonen¹

¹Learning Environments research group. School of Arts, Design and Architecture. Aalto University. Helsinki, Finland
{eva.durall, teemu.leinonen}@aalto.fi

Abstract. In education, sensor technologies are regarded with interest and new systems making use of physiological data are developed with the aim of augmenting cognition and personalize learning. This paper maps most common biomarkers associated to learning and discusses mainstream approaches adopted in education. It is claimed that students' data should be used to support self-awareness and reflection and Feeler, a design-in-progress tool that fosters reflection about learning experiences through EEG data is presented. Feeler design is carried out with research-based design methodology. The research borrows from experiential learning theory and design approaches based on inquiry and experience. Feeler design makes use of time, personal experience, the display of hidden information and incompleteness as key elements for reflection. Feeler research aims to discuss the possibilities and challenges of biomarkers in learning and education. The next stages of Feeler research include testing the prototype and iterate the design.

Keywords. biomarkers, EEG, reflection, awareness, learning

1 Introduction

In behavioural sciences, in learning science and study of education, an increasing number of scholars are working on the identification of biomarkers related to learning. Due to the close connection between cognitive functions and learning [5], most promising methods for studying users' mental context during learning come from neuroscience.

This paper discusses the use of biomarkers in learning, focusing on brain electrical activity through electroencephalographs (EEG). Concretely, it explores how this data can support students' awareness and reflection about how their mental states affect their study performance. The focus of the paper, however, is on Feeler prototype, a tangible computing device designed as part of the research. The prototype engages users in brain waves self-monitoring through an EEG device.

The following sections include a review of the most common real-time biomarkers used through non-invasive technology for monitoring learning, as well as a description of Feeler prototype. The research methodology and design strategies adopted are also described, as well as some early conclusions of the ongoing research about how to support awareness and reflection about learning through physiological data.

2 Biomarkers for monitoring learning

Much of the current literature on biomarkers connected to learning pays particular attention to the identification of mental states dealing with cognitive load, attention, meditation, mental fatigue, alertness, emotions, and stress. Table 1 presents a list of most frequently used real-time biomarkers using non-invasive technology for monitoring different aspects connected to learning. The list is not exhaustive, but it gives an overview of the main aspects tracked in education.

Table 1. Mapping of most frequently used real-time biomarkers using non-invasive technology

	EEG	Skin Conductance	Heart Rate	Pupil Dilation / Blink Rate	Body Posture / Gaze	Expression Recognition
Cognitive Load	x	x	x	x	x	
Attention	x			x	x	
Meditation	x		x			
Mental Fatigue	x	x		x	x	x
Alertness	x		x	x	x	x
Emotions	x	x	x	x	x	x
Stress	x	x	x			x

Cognitive load is a term used in cognitive psychology to describe the amount of effort that a particular task requires to the person executing it. It's a multidimensional construct that takes into consideration how mental workload dealing with learning, thinking and reasoning demands from working memory. According to cognitive load theory, the ability to learn is limited when working memory is overloaded [5].

Most popular biomarkers used for monitoring cognitive load, attention and mental fatigue are pupil dilation and EEG. Experiments focusing on pupil dilation while performing cognitive tasks have concluded that the increase in pupil size correlates to the increase of mental workload [6]. As noted by [17], blink rate decreases when subjects deal with cognitively demanding tasks.

As alternative to eye monitoring systems, EEG has proved a reasonably good technique for tracking changes in cognitive activity associated with cognitive load [12, 17]. Due to EEG data reliability, EEG has been widely adopted as a technique for monitoring all mental states connected to learning. Despite accurate interpretations of EEG can be complex, changes between different mental states can be easily spotted. As a short summary, delta waves can be linked to deep sleep, theta to deep relaxation and meditation and alpha to states in which the person is physically and mentally relaxed. Beta would be predominant when the person is awake and gamma when she is performing cognitively demanding tasks. EEG has been used not only to monitor

but also to enhance learning. For instance, in neurofeedback EEG has been also applied to activate specific aspects of people's cognitive performance [16].

During last decades, several scholars have recognized the importance of emotions in learning [7]. As a consequence, an increasing body of research is exploring how to monitor learners' emotions in order to give feedback to educators, personalize students' learning experiences and create awareness with the aim of enhancing self-regulation skills. Most popular biomarkers used in the field of emotion are skin conductance [10] and expression recognition [1].

Skin conductance has also been used for detecting stress. In education, stress can enhance or block learning and memory [11]. Therefore, biomarkers that indicate stress based on changes in skin conductance and heart rate have been used to improve user experience by designing systems that identify and react to user's stress levels [9].

In formal education, research on biomarkers associated to learning has been used to personalize learning and inform the design of augmented cognition systems. Augmented cognition is an interdisciplinary research field that seeks to measure users' cognitive status with the aim of creating applications that regulate the information flow according to the users' cognitive capacity. Despite augmented cognition environments can be a powerful tool for leveraging cognitive load and improving efficiency when dealing with complex information, its' use in formal education contexts poses some challenges. For instance, in many occasions biomarkers are not directly related to learning, but to the conditions that are considered necessary for learning to occur. In addition, it's important to note the difficulty to define some general standards that could be applied to identify individual mental states. Considering the opportunities that the monitoring of physiological data offers for supporting learners' self-understanding, rather than personalizing learning environments that make use of biomarkers should be oriented to create awareness and reflection. Feeler design research makes use of EEG data to foster learners' thinking about their mental activity when studying.

3 Feeler: a reflective tool based on EEG self-monitoring

Feeler is a prototype created in the framework of a research looking for solutions to help people develop awareness on how different habits and mental states have an impact on their learning. The aim of Feeler research is to encourage reflection about physiological data related to learning, such as brain wave activity, in order to improve learning experiences.

Feeler is built around a script that structures a study activity in three stages. The tangible computing tools are guiding students to realize the scrip. The stages are

1. Meditation: user receives guidance to perform deep breathing and relaxation exercise before studying.
2. Study: users' online search behavior is monitored and some metadata is saved. The metadata is visualized once the study session has ended.
3. Self-assessment: Once time for study is over, user is encouraged to answer some reflective questions about their activity.



Fig. 1. Feeler interactive tangible objects and screen capture of the data visualization.

Feeler scenario of use draws on research demonstrating the positive effects of meditative practices on cognitive performance [3]. EEG about mental states is monitored during the whole session. This data is sent to a desktop app that visualizes the information once the user has ended the study session. The information recorded includes: meditation and attention levels, as well as brain waves (delta, theta, alpha, beta, gamma) and blink rate.

During the activity, within the headset that monitors EEG activity, students are given a set of physical, computational blocks that guide their actions during the different stages (figure 1). By interacting with each block, students receive instructions about the task through visual and haptic feedback. Although brain waves data is monitored throughout all the study activity, this information is not displayed in the devices.

4 Research and Design Methodology

Feeler design is carried out with research-based design methodology [14], which identifies 4 phases in the design process: Contextual Inquiry, Participatory Design, Product Design and Design of Prototype as Hypothesis. The design activity is characterized for being highly iterative and should not be understood as a linear process [14].

So far, 6 semi-structured interviews, 2 focus groups (5 attendants in each one) and 3 co-design workshops (number of participants ranged from 5 to 4 people) have conducted as part of the contextual inquiry and participatory design research (N=22). In all cases, participants were high education students with ages comprised between 25 and 45 years old. Their countries of origin were America, Europe and Asia.

The interviews and the focus groups were part of the Contextual Inquiry research. In these cases, the aim was to define the design space and identify main possibilities and design challenges. Interviewees were asked to define through pictures and in their own words the following concepts: health, mindfulness and well-being. In the workshops, participants were invited to explore how well-being could be connected to learning through self-monitoring. With this aim, a design game about reflection on self-monitored data was created. Main conclusions extracted from the workshops

dealt with the amount of data that should be visualized, as well as the difficulty to find learning indicators. Regarding the data visualization, participants showed interest in having access to the raw data, although they also highlighted the need of some initial analysis that helped them make sense out of it. In relation to learning, students considered necessary to distinguish between learning and academic activity since, from their point of view, learning is not limited to their studies and takes place in very different situations and contexts.

The 3 co-design workshops organized as part of the Participatory Design stage made use of the feedback obtained during the Contextual Inquiry and helped to extend understanding on how to monitor learning and visualize information. These workshops were conducted with students of Kyushu University Design School. Students expressed interest in ambient visualizations and their wish to access different information levels in the visualization design. Main design constraints dealt with students' short time for reviewing the data, as well as strong privacy concerns.

The empirical data gathered during the Contextual and Participatory Design stages informed Feeler Product Design. Literature from educational and design research was reviewed in order to support awareness and reflection on self-monitored data.

Feeler design builds on experiential learning cycle [13] in which reflection is understood as a cyclic process characterized by concrete/abstract and action/reflection dialectics. From this perspective, learning is tightly connected to experience and it involves all areas of human functioning (thinking, feeling, perceiving and behaving). In Feeler, we expect that the concrete experience of monitoring EEG activity would support reflective observation, which would enable some abstract conceptualization. These hypotheses could be tested through active experimentation that would lead to the production of concrete experiences. Feeler is designed as a tool for self-knowledge, so behavior change is not considered as a priority.

Despite workshop participants did not express clear interest in monitoring their brain wave activity, Feeler design focuses on the visualization of EEG data. This decision was motivated by [6]'s technology levels of reflection, concretely the one labeled as *Dialogic reflection*. According to [6], the presentation of "hidden information", such as the obtained through self-monitoring can support awareness and reflection by fostering users' curiosity. Due to the close connection between EEG and learning, the display of this type of data can help people increase understanding on their mental activity by making connections and seeing things from multiple perspectives.

The design approaches for supporting reflection that are taken into consideration during Feeler research are slow technology, inquisitive design and technology as experience. Slow technology [8] is a design philosophy in which time is considered as a prerequisite for reflection. As students' feedback showed, the time they are willing to allocate to reflect on their own activity, no matter what benefits it may bring in the future, is quite short. In Feeler, the introduction of a script slows down the academic activity with the aim of encouraging students to take the time to think about their study performance in relation to their EEG data.

Inquisitive design and technology as experience emphasize the role of experience when designing for reflection. Inquisitive design [4] introduces experience and con-

flict as key elements to support deep thinking through exploration and experimentation. The visualization of personal data in Feeler prototype is expected to create a strong link with participants since they have a first hand experience that, hopefully, will motivate them to explore the data more deeply. The decision to let the users interpret the data recorded during the session (gamma, beta, alpha, theta and delta activity, as well as meditation, attention and blink rate) creates some uncertainty and act as the basis of an inquiry process in which students identify and explore how different mental states affect their study performance.

With the term technology as experience, [15] calls for the need to develop richer models for HCI that truly take into consideration experience and how people make sense of it. Openness and incompleteness are presented as part of the strategies that designers can use to support dialogic relations between different stakeholders. The last module of Feeler tangible prototype presents the user three questions: 1) How did you feel during the session? 2) What do you expect from EEG data and 3) What would you change for next session? These interrogations are intended to support reflection and help them contrast their subjective experience with the physiological data monitored by the system.

The analysis of the information gathered through the workshops has been used to develop the first Feeler prototype, which is part of the Product Design stage. This design will be tested with MA students of Aalto Medialab and more iterations are expected in the short term.

5 Conclusions

In this paper Feeler prototype is presented as a learning tool that supports awareness and reflection about study activity through EEG data. Feeler design is based on the assumption that learning technology based on monitoring physiological data should aim to empower students by helping them understand the different aspects that have an impact on their learning performance. Therefore, Feeler research explores several strategies for supporting reflection in the prototype design such as the creation of time, asking reflective questions and leave some aspects incomplete in order to encourage users to inquire its meaning.

The methodology adopted, research based design, is strongly influenced by participatory design and human-centered design. Despite that the Feeler research is still ongoing, we consider relevant sharing the research approach and early conclusions in order to open the discussion on the role of physiological data for supporting awareness and reflection in learning.

6 References

1. Bartlett, M., Whitehill, J.: Automated facial expression measurement: Recent applications to basic research in human behavior, learning, and education. Handbook of Face Perception. Oxford University Press, USA (2010)

2. Beatty, J.: Task-evoked pupillary responses, processing load, and the structure of processing resources. *Psychological bulletin* 91, vol. 2, 276 (1982)
3. Broderick, P. C., Metz, S.: Learning to BREATHE: A pilot trial of a mindfulness curriculum for adolescents. *Advances in School Mental Health Promotion* 2, vol. 1, 35–46 (2009)
4. Dalsgaard, P.: Designing for inquisitive use. In: *Proc. of DIS*, pp.21–30 (2008)
5. DeJong, T.: Cognitive Load Theory, Educational Research, and Instructional Design: Some Food for Thought. *Instructional Science: An International Journal of the Learning Sciences* 38, 105–134 (2010)
6. Fleck, R., Fitzpatrick, G.: Reflecting on reflection: framing a design landscape. In: *Proceedings of the 22nd Conference of the Computer-Human Interaction Special Interest Group of Australia on Computer-Human Interaction*, pp. 216–223. ACM (2010)
7. Goleman, D.: *Emotional intelligence*. Bantam Books, New York (1995)
8. Hallnas, L., Redstrom, J.: Slow Technology – Designing for Reflection. *Personal & Ubiquitous Computing* 5, vol. 3, 201–212 (2001)
9. Healey, J., Picard, R. W.: Detecting stress during real-world driving tasks using physiological sensors. *Intelligent Transportation Systems, IEEE Transactions on* 6, vol. 2, 156–166 (2005)
10. Ikehara, C. S., Crosby, M. E.: Assessing cognitive load with physiological sensors. In: *System Sciences, 2005. HICSS'05. Proceedings of the 38th Annual Hawaii International Conference on*, pp. 295a–295a. IEEE (2005)
11. Joëls, M., Pu, Z., Wiegert, O., Oitzl, M. S., Krugers, H. J.: Learning under stress: how does it work?. *Trends in cognitive sciences* 10, vol. 4, 152–158 (2006)
12. Kilseop, R., Rohae, M.: Evaluation of mental workload with a combined measure based on physiological indices during a dual task of tracking and mental arithmetic. *International Journal of Industrial Ergonomics* 35, vol. 11, 991–1009 (2005)
13. Kolb, D. A.: *Experiential Learning: Experience as the Source of Learning and Development*. Prentice-Hall, Englewood Cliffs, N.J. (1984)
14. Leinonen, T.: *Designing learning tools. Methodological insights*. Ph.D. dissertation, Dept. of Media, Aalto University School of Art and Design, Bookwell, Jyväskylä (2010)
15. McCarthy, J., Wright, P.: *Technology as experience*. MIT Press, Cambridge, MA (2004)
16. Vernon, D., Egner, T., Cooper, N., Compton, T., Neilands, C., Sheri, A., Gruzelier, J.: The effect of training distinct neurofeedback protocols on aspects of cognitive performance. *International journal of psychophysiology* 47, vol. 1, 75–85 (2003)
17. Wilson, G.F.: An analysis of mental workload in pilots during flight using multiple psychophysiological measures. *International Journal of Aviation Psychology* 12, vol. 1, 3–18 (2002)
18. Pope A.T., Bogart E.H., Bartolome D.S.: Biocybernetic system evaluates indices of operator engagement in automated task. *Biological Psychology* 40, vol. 1, 187–195 (1995)
19. Smith, P., Shah, M., da Vitoria Lobo, N.: Monitoring head/eye motion for driver alertness with one camera. In: *icpr*, pp. 4636. IEEE (2000)
20. Smolders, K. C., De Kort, Y. A., Cluitmans, P. J. M.: A higher illuminance induces alertness even during office hours: Findings on subjective measures, task performance and heart rate measures. *Physiology & Behavior* 107, vol. 1, 7–16 (2012)
21. Vernon, D., Egner, T., Cooper, N., Compton, T., Neilands, C., Sheri, A., Gruzelier, J.: The effect of training distinct neurofeedback protocols on aspects of cognitive performance. *International journal of psychophysiology* 47, vol. 1, 75–85 (2003)
22. Wilson, G.F.: An analysis of mental workload in pilots during flight using multiple psychophysiological measures. *International Journal of Aviation Psychology* 12, vol. 1, 3–18 (2002)

Mood in the City - Data-Driven Reflection on Mood in Relation to Public Spaces

Viktoria Pammer¹

Knowledge Technologies Institute, Graz Univ. of Technology
Know-Center
Graz, Austria

Abstract. This paper maps out the design space of urban location-related mood self-tracking as starting point for individual and urban reflection: What are the benefits for key stakeholders, and what are system design options? Data-driven reflection here means that reflection is based on data; in this instance taking mood related to public spaces as starting point for reflection, but “attaching” to mood additional data that contains information about context such as comments, tags or pictures. We argue that individual citizens could become aware of own mood and act on this knowledge, e.g., intentionally seeking relaxing or stimulating places. Urban reflection means both discourse on the liveability of public spaces amongst citizens and by stakeholders who manage or decide on the design of public spaces in cities, the most obvious of whom are city government or building project organizers.

1 Mood in the City

Reality impacts humans’ affective states; in public spaces, their design as well as the actions and interactions of other people impact the affective states of all who pass through. The relationship of mood and places has been of interest to all sorts of people for a variety of reasons: In “the pursuit of urban happiness”¹, researchers and (city) designers investigate what sort of city design makes people feel happy and relaxed. To this purpose, plans for building highways were cancelled in Bogota in 1998 and cycle lanes were planned instead². Since then, computer scientists have taken an interest and become involved. An initiative called *urbangems*³ analysed Google street view images of London with state-of-the-art image analysis methods, and used crowdsourcing to rate images in the dimensions beauty, happiness, quietness, deprivation. The authors found that the amount of greenery is the most positively associated visual cue with beauty, happiness and quietness [15]. Similar results are found in a study based on geo-tagged tweets [1]. In [16], the authors used these findings as basis for providing

¹ www.researchswinger.net

² <http://www.bbc.com/travel/feature/20130828-reclaiming-the-streets-in-bogata>

³ www.urbangems.org

directions within a city that are not based on length of route (shortest path recommended) but on emotional pleasantness. As self-tracking technology has become available and acceptable to the masses, galvanic skin response trackers are used in the *bio mapping*⁴ initiative to automatically track emotional arousal of study participants in conjunction with their geographic location. The underlying rationale is to “become aware of our own and each others’ unique body reactions to the environment [to] create a better world” (ibid). In addition to these societally motivated works and initiatives on a socially larger scale, mood tracking is also used for more individualistic purposes. A plethora of mood self-tracking apps exist on the web⁵ in the Quantified Self spirit. Other works have investigated mood tracking more scientifically: The affective diary [17] investigated mood representations and reflections on it throughout the day, emphasising in research questions however the automatic capture of mood and its representations. AffectAura [11] explored user reactions to long-term representation of automatic emotion detection. The authors found that a historic representation of affective data does support memory, but is without “cues” (contextual data) insufficient to reconstruct memory; thus mood data cannot be the only data but needs to be connected to contextual information. The authors did not explore reflective learning however. In [12], a system for location-based emotion tagging has been developed, but not evaluated or used by a significant number of users (WiMo). Within WiMo, users can decide to share their mood tags with others via places. All mood entries are sent to a WiMo server. Note that in all the above-described related work, mood tracking is sometimes manual, and sometimes “automatic” via sensors that approximate mood via physiological reactions. Sharing in these apps fulfils as main purpose that of communicating own mood, but not that of reflecting together, or reflecting on mood in relationship to others’ mood. Finally, I myself have been part of a research team that has explored shared mood tracking in the workplace, finding indications for shared mood tracking to improve collaboration in virtual meetings [4] and work performance in call centers [5].

2 Reflective Learning

Reflective learning (which I will use as synonymous with “reflection”) is the process of critically exploring the past in order to learn for the future (see e.g. [2]). As such, reflective learning means reviewing the past in order to learn for the future. Learning is to be taken broadly: Learning means changing one’s perspective, one’s perception, one’s knowledge, planning to act differently in the future, or actually doing so (ibid). It is this direction towards the future, which distinguishes reflective learning from rumination or “mere” awareness; although awareness is a precondition for reflective learning.

Reflective learning can be understood as a cognitive process as well as a social process [14]. In the first case, it is the individual actor who learns (individual

⁴ www.biomapping.net

⁵ For instance: <http://www.moodjam.com>, <http://www.moodscope.com>

learning), while in the second case it is a social entity that learns via its members negotiating understanding, best practices, or pre-scribed processes (collaborative learning). In organisational contexts, reflection is seen as key driver for learning (see e.g., [6,7]). In such contexts, individual and collaborative learning naturally intertwine (for examples see e.g., [8]); for instance when an individual actor realises that something can only be changed at a collaborative level; or when an individual within a discussion reflects on what the discussed change in strategy will mean for own work practice.

By data-driven reflection, I mean the concept that reflection can be based to a significant extent on data; going so far as deriving “triggers for reflection” (the direct reason that makes a person or group reflect, see [8]) from data. This concept is taken by different communities, such as learning analytics, quantified self [3] or personal informatics [10].

3 Contribution: Data-Driven Reflection on Mood in Relation to Public Spaces

In this paper, I investigate data-driven reflection on mood in relation to public spaces. This is a novel concept, both for the field of computers and learning, and for the fields of social innovation and urban development. While the concept of data-driven reflection is not new for the first; it is new for the latter. Vice versa, while using something like “bottom-up dialogue” in an urban context is new in the scientific discourse in computer-supported learning, it is a big part of “business as usual” in social innovation and urban development.

I frame the task of driving social innovation and urban development bottom-up as a similar one to reflective learning in organisations: There is a mixture and inter-relationship of individual and collaborative reflection processes, and it is different stakeholders and stakeholder groups who can or should learn. I conceptualise district communities or cities as social entities that involve people with a variety of roles; from the role of “mere” citizen, to that of building project manager, to that of city official.

In this paper, I try to map out the related design space: First, I discuss the *benefits* for different stakeholders, as perceived benefit of use is one of the key predictive factors of technology acceptance. Second, I discuss *system and interaction design* directions - there is a wide variety of possibilities, and decisions will need to be taken on the path towards concretising and implementing a use case of such urban reflection as envisioned.⁶

⁶ An early version of this paper has been presented and discussed at the Smart City Learning Workshop of ECTEL 2014 and is online available at http://www.mifav.uniroma2.it/inevent/events/sclo_ectel2014/index.php?s=201&a=362. The workshop did not publish proceedings however; in addition, the paper has been updated to reflect discussions at said workshop, changes in my emerging understanding of the relationship between urban location-based mood tracking and reflective learning, and comments of ARTEL 2015 reviewers.

4 Benefits of Use

Technology acceptance has been linked, in organisational settings, to perceived ease of use and benefit [18]. In this section we discuss the potential benefits of location-related mood tracking for two key stakeholder groups in urban settings: Citizens who track their own mood in relation to places and share it in relation to public spaces, and decision makers in the public sector such as city governments or in the private sector such as building project managers.

4.1 Individual Reflection

For individuals, location-related mood tracking can serve - at a purely individual level, no sharing is necessary - to become aware of own mood in relation to places. This in turn can be useful to consciously reflect on the interaction between mood and places, and to act on this knowledge: For instance, people could use places as resources for wellbeing, and to avoid where emotionally draining places. They could also consciously aim to change their mood in relation to places, e.g., try to consciously relax in typically stressful places such as crowded public transports. Relevant individuals are not only a city's citizens, but also tourists, or people who come to a city for work. These processes are cognitive learning processes, and the goal of reflection is for individuals to improve the quality of their personal or work lives.

4.2 Urban Reflection

In prior work [13] colleagues and I analysed the functions of sharing information in relationship to reflective learning in an organisational context. We identified four major roles of sharing data for reflection: Data as basis for re-evaluation, as guideline for future behaviour, as starting point for collaborative reflection, and to integrate multiple perspectives. In urban reflection, individuals' mood in relation to public places would mainly serve as starting point for collaborative reflection. The motivation of the individual person to actually share own mood and additional information can only lie in contributing to making a city "better" - making it more liveable and enjoyable. Thus, sharing will need to be additionally facilitated by smooth and enjoyable user experience in terms of interaction with technology, together with displays of respectful and actual treatment of received input on part of responsible stakeholders, in order to achieve a suitable balance of "ease of use" with "perceived benefit" for people to actually do share their mood and comments.

Sharing own mood in relation to public spaces is, from the individual's point of view, an expression towards an audience that needs to be defined: The audience could be other citizens; thus, sharing own mood in relation to public spaces could be the starting point of an asynchronous public discourse on the "liveability" in public spaces. Shared mood could also address stakeholders that decide on and shape public spaces such as city government or building project organizers. The role of sharing own mood data (and optionally related data such as comments,

tags, pictures, etc.) corresponds to what has been called “creating awareness” in [9] as one rationale for triggering a new reflection cycle. Additionally, decision makers could also explicitly ask for focused input from citizens, tourists, people working in the city, etc. This would correspond to “seeking clarification” as rationale for starting a cycle of reflection activities [9].

The multitude of individual moods would be the starting point for re-designing cities. Such processes constitute social processes, and the goal of reflection is for the social entities of district communities (more informal) or cities (including also the formal structures) to improve the “key performance indicators” of a city: Target indicators can be defined and prioritised depending on a community’s current status, but typical indicators would be the quality of urban experience for people living in, working in, or visiting a district or city; or the financial standing of a district or city.

5 System and Interaction Design

In this section we discuss system and interaction design options, and emphasize those that we currently think preferable. Concrete design decisions will need to be explored and verified (or rejected) in future empirical studies: We will consider “valid” or “good” design decisions those that lead to appreciable benefits for key stakeholders as discussed in the above section.

We assume that mood tracking is done via mobile internet-enabled devices such as smartphones or tablets. But are users prompted to enter their mood, do they enter their mood proactively, or is a *hybrid method* implemented (e.g., via reminders)? Additionally, it is a priori unclear whether users will express only their mood or *add additional context information*, e.g., in the form of text, a photo, etc. as users are increasingly used to from other social apps and platforms. We assume, that *location does not need to be manually entered* into the system but can automatically be obtained via GPS, WiFi positioning, QR-tagged public spaces, etc. Positioning only allows for mood tracking related to the place where one currently is. It is unclear, whether in a system as proposed, mood tracking “after the fact” is desirable, e.g., stating in the evening that in the afternoon in the park one was really relaxed.

At the intersection of interaction design and software architecture we place the question of where tracked mood data are stored. In [12], all data are stored on a server, but only shared under specific circumstances. An alternative would be to share every mood entry, i.e., to view the system essentially as a public mood tracking system. At the other end of the privacy spectrum, mood tracking would be individual, and *data stored on personal mobile devices*. Mood data would only be *shared on specific user input*. On sharing, mood entries could be shared with or without usernames. The latter is most usual in social apps and platforms.

So far, we have discussed the capturing of mood. But how about interacting with location-related mood entries? We argue that users should be able to *visualise their own mood in relation to places*. But should *all users of the system get an overview of mood in the city*, or should this be reserved for city government?

Should also non-users of the system, as “users of the city”, of the public spaces, be informed about collectively tracked mood? Should shared mood be visualised only in the respective space, or should it be accessible also remotely? In all these cases, visualisation of collectively tracked mood and interactive exploration of captured mood data is an issue. In the case where every visitor of a public space should have the possibility to explore such data, interaction could be via a public website, or be mediated by an in situ ambient device.

6 Outlook

As next steps, we will concretise the above discussed benefits for multiple stakeholders as well as system and interaction design options in use cases and prototypes around participatory district development activities in Graz. Empirical studies will need to verify whether the above outlined benefits can be reached with urban location-based mood tracking.

Acknowledgements

The Know-Center is funded within the Austrian COMET Program - Competence Centers for Excellent Technologies - under the auspices of the Austrian Federal Ministry of Transport, Innovation and Technology, the Austrian Federal Ministry of Economy, Family and Youth and by the State of Styria. COMET is managed by the Austrian Research Promotion Agency FFG.

References

1. Bertrand, K.Z., Bialik, M., Virdee, K., Gros, A., Bar-Yam, Y.: Sentiment in new york city: A high resolution spatial and temporal view. Tech. rep., New England Complex Systems Institute (2013)
2. Boud, D., Keogh, R., Walker, D.: Promoting reflection in learning: a model. In: Reflection: Turning Experience into Learning, pp. 18–40. Routledge Falmer, New York (1985)
3. Choe, E.K., Lee, N.B., Lee, B., Pratt, W., Kientz, J.A.: Understanding quantified-selfers’ practices in collecting and exploring personal data. In: Proc. of the SIGCHI Conference on Human Factors in Computing Systems. pp. 1143–1152. CHI ’14 (2014), <http://doi.acm.org/10.1145/2556288.2557372>
4. Fessler, A., Rivera-Pelayo, V., Pammer, V., Braun, S.: Mood tracking in virtual meetings. In: Proceedings of the 7th European Conference on Technology Enhanced Learning. pp. 377–382. EC-TEL’12, Springer-Verlag, Berlin, Heidelberg (2012)
5. Fessler, A., Wesiak, G., Rivera-Pelayo, V., Pammer, V.: In-app reflection guidance for workplace learning. In: accepted at: 10th European Conference on Technology Enhanced Learning (ECTEL 2015) (2015)
6. Hoyrup, S.: Reflection as a core process in organisational learning. Journal of Workplace Learning 16(8), 442–454 (2004)
7. Knipfer, K., Kump, B., Wessel, D., Cress, U.: Reflection as catalyst for organisational learning. Studies in Continuing Education 35(1), 30–48 (2013)

8. Krogstie, B., Prilla, M., Pammer, V.: Understanding and Supporting Reflective Learning Processes in the Workplace: The RL@Work Model. In: Proceedings of the 8th European Conference on Technology Enhanced Learning (ECTEL 2013) (2013)
9. Krogstie, B.R., Prilla, M., Pammer, V.: Understanding and supporting reflective learning processes in the workplace: The CSRL model. In: Scaling up Learning for Sustained Impact - 8th European Conference, on Technology Enhanced Learning, EC-TEL 2013, Paphos, Cyprus, September 17-21, 2013. pp. 151–164 (2013)
10. Li, I., Dey, A.K., Forlizzi, J.: Understanding my data, myself: Supporting self-reflection with ubicomp technologies. In: Proceedings of the 13th International Conference on Ubiquitous Computing. pp. 405–414. UbiComp '11, ACM, New York, NY, USA (2011), <http://doi.acm.org/10.1145/2030112.2030166>
11. McDuff, D., Karlson, A., Kapoor, A., Roseway, A., Czerwinski, M.: Affectaura: An intelligent system for emotional memory. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp. 849–858. CHI '12, ACM (2012)
12. Mody, R.N., Willis, K.S., Kerstein, R.: Wimo: Location-based emotion tagging. In: Proceedings of the 8th International Conference on Mobile and Ubiquitous Multimedia. pp. 14:1–14:4. MUM '09, ACM (2009)
13. Pammer, V., Prilla, M., Divitini, M.: The functions of sharing experiences, observations and insights for reflective learning at work. In: Proceedings of the 2nd Workshop on Awareness and Reflection in Technology-Enhanced Learning (ARETL 2012) at ECTEL 2012. pp. 117–124. CEUR Workshop Proceedings (2012)
14. Prilla, M., Pammer, V., Balzert, S.: The push and pull of reflection in workplace learning: Designing to support transitions between individual, collaborative and organisational learning. In: 7th European Conference on Technology-Enhanced Learning (ECTEL 2012) (2012)
15. Quercia, D.: Urban: Crowdsourcing for the good of london. In: Proceedings of the 22Nd International Conference on World Wide Web Companion. pp. 591–592. WWW '13 Companion, International World Wide Web Conferences Steering Committee, Republic and Canton of Geneva, Switzerland (2013)
16. Quercia, D., Schifanella, R., Aiello, L.M.: The shortest path to happiness: Recommending beautiful, quiet, and happy routes in the city. In: Proceedings of HyperText 2014 (2014)
17. Ståhl, A., Höök, K., Svensson, M., Taylor, A.S., Combetto, M.: Experiencing the affective diary. *Personal Ubiquitous Comput.* 13(5), 365–378 (Jun 2009)
18. Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D.: User acceptance of information technology: Toward a unified view. *MIS Q.* 27(3), 425–478 (Sep 2003)

Keywords of written reflection - a comparison between reflective and descriptive datasets

Thomas Daniel Ullmann

Institute of Educational Technology, The Open University,
Walton Hall, MK7 6AA Milton Keynes, United Kingdom
t.ullmann@open.ac.uk
<http://www.open.ac.uk/iet/>

Abstract: This study investigates reflection keywords by contrasting two datasets, one of reflective sentences and another of descriptive sentences. The log-likelihood statistic reveals several reflection keywords that are discussed in the context of a model for reflective writing. These keywords are seen as a useful building block for tools that can automatically analyse reflection in texts.

Keywords: reflection detection, thinking skills analytics, log-likelihood, keyword, key word

1 Introduction

Supporting learners with opportunities for reflective practice and fostering their reflective thinking are important educational goals. The UK Quality Assurance Agency for Higher Education (QAA), for example, recommends that all teaching and learning practices be informed by reflection [1]. The Organisation for Economic Co-operation and Development (OECD) places reflection at the ‘heart of key competencies’ [2], and furthermore, the Assessment and Analytical Framework for PISA sees reflection and evaluation as part of their assessment framework for reading literacy [3].

There are many ways for expressing reflective thoughts. A common representation is reflective writing (for example, see [4,5]). Reflective writing is a piece of text that contains the reflections of the writer. For example, reflective writing can be a journal, diary, blog post, or structured worksheet.

Researchers frequently analyse reflective writings to determine reflective writing quality and evaluate the success of academic writing programmes. This analysis usually follows a content analysis approach (for example, see [6,7]). Researchers use content analysis to systematically detect all textual evidence that belongs to model categories of reflective writing. However, the content analysis of reflective writing is a time-consuming process. Automated reflection analytics techniques have the potential of reducing the amount of time necessary to analyse reflective writings.

This paper contributes to the research of automated detection of reflection in texts (for example, see [8,9,10]). The automated detection of reflection is linked to one of

the grand challenges of technology enhanced learning, which is 'e-assessment and automated feedback' [11,12]. In order to create automated systems to assist reflective writing assessment, techniques have to be developed first that can automatically detect reflection in texts. Once a system can detect reflection, this information can be used to automatically assist the assessment of reflection. Therefore, reflection detection is a base technology with the potential for several applications, for example, e-assessment and automated feedback.

For the automated detection of reflection, it is important to identify patterns or regularities found in reflective writings. These regularities bear the potential of being formalised in computer programs, which then can automatically detect these patterns of reflection in novel texts. This paper shows a method that allows the identification of reflection keywords based on the comparison of datasets with the log-likelihood statistic. It then discusses the keywords derived in the context of a model of written reflection.

2 Automated detection of reflection in texts

Research in the area of automated detection of reflection aims at the development of those techniques and technologies that can automatically identify the characteristics of reflection in texts. Three techniques have been identified that have been used to automatically analyse texts in respect to reflection [13]. They are dictionary-based, rule-based, and machine learning-based approaches. The dictionary-based approach makes use of lists/dictionaries of words. The words contained in a dictionary represent aspects of reflection. These dictionaries can be used to analyse texts with regard to the frequency of word occurrences in texts, or to visually highlight detected text passages (for example, see [8]). The rule-based approach makes use of a set of rules. Each rule captures an aspect of reflection. These rules, along with a rule-based system, allow drawing inferences from texts, and can be used to analyse reflective writings (for example, see [9]). The first two approaches make use of expert knowledge in order to construct the dictionaries or rules. The third approach makes use of machine learning. Machine learning algorithms learn regularities or patterns from many examples that represent facets of reflection [13]. The generated machine learning models classify unseen text into categories of reflection.

Although machine learning-based approaches can automatically build models to detect reflection, the first two approaches rely on explicit knowledge about either words or rules that represent aspects of reflection.

The literature of research that applied content analysis to investigate reflective writings indicated that reflective writings exhibit such textual patterns. Hatton and Smith [14] touched on language patterns that aided the coding of dialogic reflection. Fund et al. [15] noted the coordination between idea units as important for identifying reflection types. Poom-Valickis and Mathews [16] mentioned lists of keywords in order to code text units. Hawkes and Romiszowski [17] and Hawkes [18, 19] suggested an association between discourse markers and reflection. In that research, the guiding framework of the analysis was the model of reflection selected by these authors.

Another area of the research that investigates patterns of reflection makes use of systemic-functional linguistics [20–28]. This research has in common that it investigates text based on a linguistic framework in order to derive a link between the linguistic framework and reflection expressed in texts. The guiding framework for this type of research is the linguistic framework. Categories of the linguistic framework are then mapped to categories of reflective writing models in order to explore the relationship between linguistic resources and reflective writing.

The approach taken here makes use of the corpus linguistic keyword method using log-likelihood statistic as described by Rayson [29] to find reflection keywords. This method is based on the frequency analysis of two corpora/datasets in order to investigate words that occur significantly more frequently in one or another dataset. Here, the datasets consist of reflective and descriptive sentences. The keyword method is used to reveal words that are significantly more or less often used in the dataset of reflective sentences compared with the dataset of descriptive sentences.

This approach is different from the above outlined content analysis and systemic-functional approaches because it places data first, and not theory. The aforementioned approaches use theory to interpret data, whereas the approach taken here derives a set of keywords using a statistical method. These empirically derived keywords can then be interpreted in the context of theory. This is at first a data-driven approach that may inform theory [29].

The term 'keyword' has several notions, and within this paper it describes those words that occur significantly more frequently within one dataset than another [30]. Several statistical tests can be used to calculate the 'keyness' of words [31]. Here, the chosen test is the log-likelihood ratio test as described by Rayson [29] (see also [32] for a similar implementation of the log-likelihood test).

3 Models to analyse reflective writings

The datasets used to derive keywords were created according to a frequently found distinction made in research that analyses reflective writings: A text can be either descriptive/non-reflective or reflective. The lowest level is often described as descriptive, and it contains no reflection; on the other side of the scale are reflective texts, which can be further distinguished according to several levels of reflection (for example, see [33,34–38]). However, the common denominator of these models is the basic distinction between descriptive and reflective texts.

In addition to levels of reflection, research into the analysis of reflective writings proposed several models with various model categories that describe constituents of reflective writing. These model constituents describe the breadth, and not the depth, of reflection as the level models. Manual content analysis of reflective writings uses the categories that describe breadth facets of reflective writing, as well as levels of reflection as their coding category schema. Although the model categories vary from research to research, they do share some commonalities. The model used to aid in the interpretation of the keywords is based on the model for reflection detection described by

Ullmann [13]. An older version of this model can be found in the study by Ullmann et al. [9]. The breadth model categories are:

Experience: A reflective writing is often about experience or a personal matter. The description of what occurred and the capturing of the important characteristic of the situation provide the background and focal point for reflective writing. The description of the experience captures important parts of the experience, and provides the context and/or the reason for the writing. This category can be frequently found in models that analyse reflection (for example, see [6,7], [39]).

Personal: A reflective writing is often of a personal nature. This means that it is often about beliefs, personal assumptions, or knowledge about oneself. The text is written with a personal voice and shows the development of a perspective on the experience at hand. Several models describe this category (for example, see [20], [39,40]).

Feelings: Feelings can be the starting point of a reflection. Feelings often associated with reflection are the feeling of being concerned, having doubts, a feeling of uncertainty, frustration, but also feelings such as surprise or excitement. Whereas feelings can be the starting point of a reflection, they can also be the subject matter of the reflection, for example, reflections on the influence of feelings on thinking and action. Several models that analyse reflective writings contain references to this category (for example, see [7], [39,40]).

Critical stance: Expressing an alert or critical mindset is an important part of reflective writing. Having a critical stance involves being aware of problems and being able to identify or diagnose such problems. Being critical is about questioning assumptions and opinions, analysing and evaluating problems, judging situations, testing the validity of assumptions, drawing conclusions, and making decisions. This category is mentioned in many models (for example, see [6], [20], [39]).

Perspective: Although reflective writings are often written from the first person perspective, considering other perspectives is an important facet of reflective writing. Examples are the perspective of someone else, a theory; the social, historical, ethical, moral, or political context. Several content analysis models contain this category (for example, see [20], [39], [41]).

Outcome: There can be several outcomes from reflective writing. An outcome from reflective writing can be a description of lessons learned, better understanding of the situation or context, new insights, change of perspective or behaviour, and the awareness of one's way of thinking. An outcome can be also an intention to do something or any planning for the future. The category outcome is also frequently mentioned in content analysis models used to analyse reflective writings (for example, see [39], [41,42]).

These six categories, which stem directly from the research on manual content analysis of reflective writing, form the guiding framework for the interpretation of the results of keyword analysis.

4 Dataset generation process and datasets

The datasets of reflective and descriptive sentences were obtained from research that investigated the automated detection of reflection using machine learning (details are

found in [13]). These two datasets are mostly based on a sample of the British Academic Writing English Corpus (BAWE) [43,44]. The sampled texts are mostly from the disciplines of health, business, and engineering.

A sentence splitter divided each sample text from the BAWE text collection into sentences. Seven to ten raters ranked each sentence on a six-point Likert scale as to whether the sentence is descriptive or reflective. A crowdsourcing solution¹ was used to distribute the sentences to the raters. An even-numbered scale was used so that the raters had to decide whether the sentence is reflective or descriptive, and to avoid misusing the neutral point of an odd-numbered scale as the 'don't know' category. The ratings on the six-point Likert scale were then dichotomised into the class reflective and descriptive.

The aim was then to generate two datasets of approximate equal size to aid the comparison of both datasets. A sentence was only included into the dataset if it received a 4/5 majority of ratings for either belonging to the reflective or descriptive classes. The decision on which aggregation strategy to choose was based on the 4/5 majority because it represents a more strict quality standard compared with the more lenient simple majority vote. This ensures that only those sentences that received substantial support as belonging to one of the two categories were included in this study. For example, a sentence that received ten ratings was included if eight or more of the ten ratings ranked the sentence as reflective (or descriptive). Reliability estimates of the ratings aggregated with majority and 4/5 majority vote were reported by Ullmann [13], who found as substantial for the majority vote a Cohen's kappa of 0.62, and almost perfect for the 4/5 majority vote a Cohen's kappa of 0.92, according to the benchmark of Landis and Koch [45]. From this annotated dataset of highly agreed sentences, a random sample of 500 reflective sentences and 500 descriptive sentences was drawn.

All sentences from the two datasets were pre-processed with the same data generation process. This involved the removal of any punctuations, numbers, and superfluous whitespaces, sentence tokenisation to words, and word conversion to lower case. The R environment for statistical computing and graphics [46,47] was used to develop the scripts for data processing and calculation of the log-likelihood ratio.

The dataset of reflective sentences contains a total of 12,697 words (2,200 unique words). The average sentence length is 25.39 words. The dataset of descriptive/non-reflective sentences contains a total of 10,284 words (2,800 unique words). The average sentence length is 20.57 words.

5 Results

The frequency of each word of each dataset was counted and compared. Word comparison is based on the log-likelihood of the two terms [29]. The log-likelihood considers the frequency of the two terms compared with the size of the entire datasets. Table 1 lists the log-likelihood of all words with a log-likelihood higher than 10.83, which represents a p -value < 0.001 ², and an effect size calculated with the Bayes Factor² of > 2

¹ CrowdFlower (<http://www.crowdflower.com/>)

² <http://ucrel.lancs.ac.uk/llwizard.html>

[48]. Word pairs below these thresholds are not listed. Table 1 is sorted by the log-likelihood with the highest log-likelihood at the top, and the lowest at the bottom. Furthermore, the table indicates for each term, the frequency of occurrence in the datasets of reflective and descriptive sentences. The column 'Use' indicates with a + and - sign whether the term is overused ('+') in the reflective dataset, which means that it has a higher relative frequency in the reflective dataset, or underused ('-'), which means that it is more frequently used in the dataset of descriptive sentences.

For example, the word 'i' is frequently present in the dataset of reflective sentences. It occurs 700 times in the reflective dataset and 105 times in the descriptive dataset. It has the highest log-likelihood ratio of 376.07, which means that the word 'i' occurs unusually often (the column use has a '+'-sign) in the dataset of reflective sentences compared to the dataset of descriptive sentences. The word 'he' is underused in the reflective dataset (see the '-'-sign), which means it appears unusually often in the descriptive dataset according to the used log-likelihood test.

Table 1. Log-likelihood of the datasets words.

Word	Reflective dataset	Descriptive dataset	Log-likelihood	Use
i	700	105	376.07	+
have	191	35	88.09	+
me	107	8	81.75	+
my	201	56	59.11	+
feel	68	4	56.23	+
felt	61	4	48.76	+
not	117	29	39.91	+
that	285	130	31.25	+
more	78	18	28.85	+
better	30	1	28.37	+
is	72	123	26.41	-
this	157	63	24.11	+
believe	26	1	23.91	+
now	29	2	22.80	+
he	5	26	20.35	-
by	36	71	20.23	-
future	17	0	20.17	+
of	285	329	19.24	-
was	181	84	18.84	+
situation	31	4	18.34	+
think	31	4	18.34	+
are	30	61	18.32	-
if	47	11	17.12	+
would	83	29	17.01	+
and	369	402	16.92	-
but	51	13	16.82	+

Word	Reflective dataset	Descriptive dataset	Log-likelihood	Use
never	14	0	16.61	+
bit	13	0	15.43	+
system	1	13	14.89	-
their	11	31	14.60	-
could	56	17	14.55	+
ae ³	0	9	14.47	-
knowledge	5	21	14.25	-
aware	12	0	14.24	+
hindsight	12	0	14.24	+
learnt	17	1	14.06	+
although	20	2	13.54	+
probably	11	0	13.05	+
it	160	80	12.98	+
place	2	14	12.83	-
myself	22	3	12.58	+

6 Discussion

Table 1 lists the dataset words with the highest log-likelihood. Their relative frequency differs between datasets, which makes them distinctive. They are words for which it is unlikely that the null hypothesis, where their relative frequencies are the same, is true. These are the keywords defined by the statistical procedure. Their p-value and effect size act as inclusion criteria. An additional criterion could have been used to exclude words that occur relatively infrequently [30]. For example, the word 'ae' for 'A&E' (see footnote 3) occurs nine times in both datasets, which makes it the word with the least occurrences in Table 1.

In the following subsections, some of the keywords are discussed, and a link between the keywords and their belongings to one of the categories of the model of reflective writing is established. Several of the keywords are illustrated with sentences obtained from the datasets. The keywords within each sample sentence are highlighted in bold.

6.1 Experience

The description of an 'Experience' often entails the description of a situation that occurred in the past. One of the keywords directly addresses a 'situation'. An example of a sentence with this key word is, 'On the whole I felt I and the other members of staff did all they could to manage a difficult **situation** and gave Joseph more than ample

³ The word 'ae' represents 'A&E', which refers to the Accident and Emergency service. As all punctuations have been removed during the data generation process, also the '&' of A&E was removed.

opportunity to cooperate however, in **hindsight** I feel some aspects could have been handled differently'. Another example is the sentence, 'My reaction to her and the **situation** surprised me as I became quiet agitated and in **hindsight** was probably just as unaccommodating as she was'. The two sentences also contain the keyword 'hindsight', which is used to express a retrospective understanding of a situation.

6.2 Personal

It is notable that first person singular pronouns, such as 'I', 'me', 'my', and 'myself', are keywords overused in the reflective dataset. This may indicate that reflective writings are frequently written from the first person perspective, which is also in line with the category 'Personal' of the reflection model as outlined above. The third person singular pronoun 'he' is more associated with a descriptive text. The category 'Personal' is also about own beliefs. The keyword 'believes' may be indicative for expressing beliefs. The following sentence is an example of this: 'Reflecting about conflicts I had in the past, I **believe** that I could have handled some of them better'. Another example of this is the sentence, 'When the time came to allocate work for the plan I **believe** the team dynamics were developed enough to assess accurately everybody's strengths and apportioned work accordingly'. The modal verb 'would' can also refer to beliefs. An example is the sentence, 'I felt that as team leader I **would** have control in the group and I **would** have more say in the way our team was run, little did I know then'. Another example is the sentence, 'Knowing about the tradition, I **would** definitely have acted differently, hopefully being in the position to speak at least a bit of the language'.

6.3 Feelings

The words 'feel' and 'felt' are at top of the list, and they occur relatively more often in the dataset of reflective sentences. This is in line the category 'Feelings' of the reflection model. Expressing feelings is often mentioned as part of reflective writing.

6.4 Critical stance

Several words can be associated with the category 'Critical stance', for example, the keywords: 'more', 'better', 'if', 'but', 'never', 'could', and 'although'.

The word 'more' could relate to the critical thought of a writer that something is lacking and that more of something would be better, or it could relate to the realisation that there is now more of something that was previously not there. For example, the sentence, 'I should be **more** aware about the power issues and how they silence patients', expresses the first sense, which is the realisation that something is still lacking. The sentence, 'I noticed **more** discussions taking place after the first couple of sessions, and I felt our group was **more** established as we began to get to grips with what the vignette would entail and felt comfortable with each other', refers to the second meaning—the realisation of a change.

The word 'better' could refer to the critical awareness of the writer that something is now better, as expressed in the sentence, 'I hadn't really thought of it like this before

but by empathising with Mary's situation I **better** appreciate the importance of the patient's perspective'. It could also express that something should have been better, as in the sentence, 'I might have **better** explored Jim's internal thoughts and his wondering about what he finds in the cave'.

The conjunction 'if' could express a premise followed by a conclusion as part of reasoning about something. For example, the sentence, 'It would have been helpful **if** I had shared my concerns about the group with the LSA to start with'. If he had shared his concerns (premise), then it would have been helpful (conclusion).

The conjunction 'but' could express a contrasting thought. An example is the sentence, 'Looking at it from Marissa's point of view, she may have known that I was on the wrong track, **but** she probably would not have been able to do anything about it because I am a doctor'. Another example is the sentence, 'I did not do all that well in the exam so maybe I need to prepare differently - **but** I really don't know how to do it'.

A writer could flag with the adverb 'never' a realisation that something was never experienced or that something never happened before. The following sentence is indicative for this: 'In the topic I found it most interesting about the lack of invariance problem as I have **never** realised the fact before although the point is reasonably understandable'. Another example is the following sentence: 'I had **never** experienced those same feelings of disconnect in real time though, **never** felt as though the person talking was somehow not me, until last Tuesday'.

The verb 'could' might indicate the awareness of a possibility or alternative. The sentence, 'On the whole our group worked well but **could** have been improved by more openness and discussion about issues affecting the group, such as social loafing', shows that the writer describes a realisation that there is a real possibility for improvement. Another example is the sentence, 'Reflecting about conflicts I had in the past, I believe that I **could** have handled some of them better'.

The word 'although' could be used in a contrasting way. An example is the following sentence: '**Although** throughout my training to date, I have dutifully reflected on various clinical situations and considered learning objectives within the practice portfolio; I can not say that I had actually fully taken on the implications of what it is to be a truly reflective practitioner'. The writer describes the contrast between the perception of reflection in previous trainings and the current perception. Another example is the sentence, 'Applying the learning cycle proved to be a useful tool, **although** I was very sceptic at the beginning'. This sentence describes a contrast in perception. The sceptical few dissolved over time.

6.5 Perspective

The keyword list from Table 1 does not contain a keyword that allows us to establish a strong link between a keyword and the category 'Perspective'.

6.6 Outcome

The 'Outcome' category of the model contains a retrospective dimension that entails, for example, the description of lessons learned, but also a prospective dimension directed to statements about what to do in future. The keyword list contains the word 'learnt'. This word could express that something was learned. An example of this outcome facet is the sentence, 'I have **learnt** that when I am requesting something different, I must explain my needs fully, and communicate the message more effectively'. Another example is the sentence, 'I have also **learnt** from participating in this group that I was, in this case, one of the more dominant group members, and felt confident in expressing my views and ideas'. Another keyword is the noun 'future'. This keyword could be used to express future intentions. An example is the sentence, 'Although this situation didn't have a satisfactory outcome I hope to have learned from the experience and aim to use my new insight to develop my **future** practice'. Another example is the sentence, 'This makes you realise that you could come across this within the profession and luckily from this activity I am now aware of this and I can now make the most of any opportunities that arise to enable me to take this into account and maybe build up my confidence so in the **future** I can maybe go on to stand up for what I believe in and also get my opinions noticed if I feel this necessary'.

6.7 Summary

Overall, this discussion showed that for several keywords, the log-likelihood statistic can derive words that are in line with the categories of the chosen model of reflection.

The keywords listed in Table 1 can be seen as good candidate words for the construction of dictionaries. With the shown approach, we can form a set of words, such as a dictionary, that can be used to automatically summarise texts with regard to the frequency of occurrence for each category. However, Table 1 also shows that words, although they are found frequently in one dataset, cannot be used to distinguish completely between reflective and descriptive use. For example, the keyword 'I' is found 700 times in the reflective dataset, but 'I' is also used 105 times in the dataset of descriptive sentences. A definite classification of text passages based on single words is also not the aim of dictionary-based approaches. One of the use cases there is that the dictionaries are used to predict important outcomes. This is a quantitative indicator that can be used to corroborate the findings of a study (for example, see [49]).

7 Conclusion and outlook

This paper demonstrated the application of the keyword method on a dataset of reflective and descriptive sentences. The log-likelihood statistics was used to determine words with high 'keyness' in either the dataset of reflective sentences or that of descriptive sentences. The words derived with the described method represent words that occur with unusual relative frequency in the datasets. In the discussion of the results, several of these keywords were assigned to categories of a model of reflective writing. This step illustrated that the investigated keywords can be associated with the reflection

model categories. This supports the applicability of the keyword method to derive words important for reflection.

An extension of the shown approach is to investigate the 'keyness' of the categories of the reflection model. For example, a comparison of a dataset that describes the outcomes of reflective writings with a reference dataset would allow us to derive keywords of reflection outcomes by adding an in-depth study of keywords for this category.

Furthermore, reflection dictionaries can be combined with rule-based systems [9]. Rule-based systems provide more control in modelling relationships between dictionary words, which could add to the precision of the automated method.

As outlined, the automated detection of reflection in writings relies on patterns of reflection, because these patterns can be codified and used for the automated analysis of writings. The study showed that reflective writings contain such patterns at the word level, because there are words that occur significantly more often in the dataset of reflective sentences than in the dataset of descriptive sentences.

8 References

1. QAA: UK quality code for higher education. Part B: Assuring and enhancing academic quality. Chapter B3: Learning and teaching. (2012).
2. Rychen, D.S., Salganik, L.H.: The Definition and Selection of Key Competencies: Executive Summary. OECD (2005).
3. OECD: PISA 2012 Assessment and Analytical Framework. OECD Publishing (2013).
4. Dymont, J.E., O'Connell, T.S.: The Quality of Reflection in Student Journals: A Review of Limiting and Enabling Factors. *Innovative Higher Education*. 35, 233–244 (2010).
5. Moon, J.A.: *Learning Journals: A Handbook for Reflective Practice and Professional Development*. Routledge (2006).
6. Poldner, E., Van der Schaaf, M., Simons, P.R.-J., Van Tartwijk, J., Wijngaards, G.: Assessing student teachers' reflective writing through quantitative content analysis. *European Journal of Teacher Education*. 37, 348–373 (2014).
7. Prilla, M., Renner, B.: Supporting Collaborative Reflection at Work: A Comparative Case Analysis. In: *Proceedings of the 18th International Conference on Supporting Group Work*. pp. 182–193. ACM Press, New York, NY, USA (2014).
8. Ullmann, T.D.: An Architecture for the Automated Detection of Textual Indicators of Reflection. In: Reinhardt, W., Ullmann, T.D., Scott, P., Pammer, V., Conlan, O., and Berlanga, A. (eds.) *Proceedings of the 1st European Workshop on Awareness and Reflection in Learning Networks*. pp. 138–151. CEUR-WS.org, Palermo, Italy (2011).
9. Ullmann, T.D., Wild, F., Scott, P.: Comparing Automatically Detected Reflective Texts with Human Judgements. In: Moore, A., Pammer, V., Pannese, L., Prilla, M., Rajagopal, K., Reinhardt, W., Ullmann, T.D., and Voigt, C. (eds.) *2nd Workshop on Awareness and Reflection in Technology-Enhanced Learning*. CEUR-WS.org, Saarbruecken, Germany (2012).

10. Ullmann, T.D., Wild, F., Scott, P.: Reflection - quantifying a rare good. In: Kravcik, M., Krogstie, B.R., Moore, A., Pammer, V., Pannese, L., Prilla, M., Reinhardt, W., and Ullmann, T.D. (eds.) *Proceedings of the 3rd Workshop on Awareness and Reflection in Technology-Enhanced Learning*. pp. 29–40. CEUR-WS.org, Paphos, Cyprus (2013).
11. Sutherland, R., Eagle, S., Joubert, M.: *A vision and strategy for Technology Enhanced Learning: Report from the STELLAR Network of Excellence*. (2012).
12. Fischer, F., Wild, F., Sutherland, R., Zirn, L. eds: *Grand Challenges in Technology Enhanced Learning - Outcomes of the 3rd Alpine Rendez-Vous*. Springer International Publishing (2014).
13. Ullmann, T.D.: *Automated detection of reflection in texts - A machine learning based approach*. PhD thesis The Open University (submitted).
14. Hatton, N., Smith, D.: Reflection in teacher education: Towards definition and implementation. *Teaching and Teacher Education*. 11, 33–49 (1995).
15. Fund, Z., Court, D., Kramarski, B.: Construction and Application of an Evaluative Tool to Assess Reflection in Teacher-Training Courses. *Assessment & Evaluation in Higher Education*. 27, 485–499 (2002).
16. Poom-Valickis, K., Mathews, S.: Reflecting others and own practice: an analysis of novice teachers' reflection skills. *Reflective Practice*. 14, 420–434 (2013).
17. Hawkes, M., Romiszowski, A.: Examining the reflective outcomes of asynchronous computer-mediated communication on inservice teacher development. *Journal of Technology and Teacher Education*. 9, 285–308 (2001).
18. Hawkes, M.: An analysis of critically reflective teacher dialogue in asynchronous computer-mediated communication. In: *IEEE International Conference on Advanced Learning Technologies, 2001. Proceedings*. pp. 247 –250 (2001).
19. Hawkes, M.: Linguistic Discourse Variables as Indicators of Reflective Online Interaction. *American Journal of Distance Education*. 20, 231–244 (2006).
20. Birney, R.: *Reflective Writing: Quantitative Assessment and Identification of Linguistic Features*, <http://repository.wit.ie/2658/>, (2012).
21. Forbes, A.: Evidence of learning in reflective practice: a case study of computer-assisted analysis of students' reflective blogs. *New Zealand Association for Cooperative Education 2011 Conference Proceedings*. 11–14 (2011).
22. Luk, J.: Assessing teaching practicum reflections: Distinguishing discourse features of the “high” and “low” grade reports. *System*. 36, 624–641 (2008).
23. Reidsema, C., Mort, P.: Assessing reflective writing: Analysis of reflective writing in an engineering design course. *Journal of Academic Language and Learning*. 3, A117–A129 (2009).
24. Ryan, M.: Improving reflective writing in higher education: a social semiotic perspective. *Teaching in Higher Education*. 16, 99–111 (2011).
25. Ryan, M.: Conceptualising and teaching discursive and performative reflection in higher education. *Studies in Continuing Education*. 34, 207–223 (2012).
26. Ryan, M.: Reflexive writers: Re-thinking writing development and assessment in schools. *Assessing Writing*. 22, 60–74 (2014).

27. Shaheed, N., Dong, A.: Reflection and analysis in design student blogs. DS 36: Proceedings DESIGN 2006, the 9th International Design Conference, Dubrovnik, Croatia. (2006).
28. Wharton, S.: Presenting a united front: assessed reflective writing on a group experience. *Reflective Practice*. 13, 489–501 (2012).
29. Rayson, P.: From key words to key semantic domains. *International Journal of Corpus Linguistics*. 13, 519–549 (2008).
30. Scott, M.: PC analysis of key words — And key key words. *System*. 25, 233–245 (1997).
31. Lijffijt, J., Nevalainen, T., Säily, T., Papapetrou, P., Puolamäki, K., Mannila, H.: Significance testing of word frequencies in corpora. *Digital Scholarship in the Humanities*. fqu064 (2014).
32. Dunning, T.: Accurate methods for the statistics of surprise and coincidence. *Computational linguistics*. 19, 61–74 (1993).
33. Ballard, K.K.: Using Van Manen’s model to assess levels of reflectivity among preservice physical education teachers, <https://repository.tamu.edu/handle/1969.1/4373>, (2006).
34. Ip, W.Y., Lui, M.H., Chien, W.T., Lee, I.F., Lam, L.W., Lee, D.: Promoting self-reflection in clinical practice among Chinese nursing undergraduates in Hong Kong. *Contemporary Nurse*. 41, 253–262 (2012).
35. Kember, D., Jones, A., Loke, A., McKay, J., Sinclair, K., Tse, H., Webb, C., Wong, F., Wong, M., Yeung, E.: Determining the level of reflective thinking from students’ written journals using a coding scheme based on the work of Mezirow. *Int. J. of Lifelong Educ.* 18, 18–30 (1999).
36. Lai, G., Calandra, B.: Examining the effects of computer-based scaffolds on novice teachers’ reflective journal writing. *ETR&D-Educ. Tech. Res. Dev.* 58, 421–437 (2010).
37. McCollum, S.: Insights Into the Process of Guiding reflection During an Early Field experience of Preservice Teachers. (1997).
38. Sparks-Langer, G.M., Simmons, J.M., Pasch, M., Colton, A., Starko, A.: Reflective Pedagogical Thinking: How Can We Promote It and Measure It? *Journal of Teacher Education*. 41, 23–32 (1990).
39. Wald, H.S., Borkan, J.M., Taylor, J.S., Anthony, D., Reis, S.P.: Fostering and Evaluating Reflective Capacity in Medical Education: Developing the REFLECT Rubric for Assessing Reflective Writing. *Academic Medicine*. 87, 41–50 (2012).
40. Wallman, A., Lindblad, A.K., Hall, S., Lundmark, A., Ring, L.: A Categorization Scheme for Assessing Pharmacy Students’ Levels of Reflection During Internships. *Am J Pharm Educ.* 72, (2008).
41. Plack, M.M., Driscoll, M., Marquez, M., Cuppernull, L., Maring, J., Greenberg, L.: Assessing Reflective Writing on a Pediatric Clerkship by Using a Modified Bloom’s Taxonomy. *Ambulatory Pediatrics*. 7, 285–291 (2007).
42. Plack, M.M., Driscoll, M., Blissett, S., McKenna, R., Plack, T.P.: A method for assessing reflective journal writing. *Journal of allied health*. 34, 199–208 (2005).
43. Gardner, S., Nesi, H.: A Classification of Genre Families in University Student Writing. *Applied Linguistics*. 34, 25–52 (2013).

44. Nesi, H., Gardner, S.: *Genres across the disciplines: Student writing in higher education*. Cambridge University Press (2012).
45. Landis, J.R., Koch, G.G.: The Measurement of Observer Agreement for Categorical Data. *Biometrics*. 33, 159–174 (1977).
46. R Core Team: *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria (2014).
47. Feinerer, I., Hornik, K.: *tm: Text Mining Package*. (2014).
48. Wilson, A.: Embracing Bayes factors for key item analysis in corpus linguistics. In: Bieswanger, M. and Koll-Stobbe, A. (eds.) *New approaches to the study of linguistic variability*. pp. 3–11. Peter Lang, Frankfurt (2013).
49. Chung, C.K., Pennebaker, J.W.: Linguistic Inquiry and Word Count (LIWC): Pronounced “Luke” and Other Useful Facts. In: McCarthy, P.M. and Boonthum, C. (eds.) *Applied Natural Language Processing and Content Analysis: Advances in Identification, Investigation and Resolution*. pp. 206–229. Information Science Reference (an imprint of IGI Global), Hershey, United States of America (2012).

The LearnWeb Formative Assessment Extension: Supporting Awareness and Reflection in Blended Courses

Alana Morais¹, Ivana Marenzi², Deirdre Kantz³

¹ Universidade Federal de Campina Grande, 58429-900 Campina Grande-PB, Brazil
alanamorais@copin.ufcg.edu.br

² Leibniz Universität Hannover, L3S Research Centre, 30167, Hannover, Germany
marenzi@l3s.de

³ University of Pavia, Centro Linguistico (Faculty of Medicine), 27100 Pavia, Italy
dkantz@unipv.it

Abstract. Blended solutions provide a means to orchestrate various types of activities and to schedule interactions at different times, nonetheless it is difficult to maintain a general overview of the class. In this paper, we build on the LearnWeb Design Framework to design and implement a Formative Assessment extension that supports the monitoring of the learning process in order to increase awareness and support reflection in a specific learning scenario. The extension offers a common basis for the various stakeholders (researchers, teachers and students) to collaboratively reflect on and design effective learning activities.

Keywords: Awareness, formative assessment, co-design, reflection, TEL.

1 Introduction

Very often University courses entail large numbers of students which makes it difficult to design and carry out learning tasks, as well as to assess learning outcomes [13].

The use of technology makes it possible to record the tracks of student activity and to provide the teacher with dedicated analytics to improve awareness [2-3,12]. Learning analytics techniques are a valuable tool to support formative assessment practices that are based on two main pillars: (1) the collection of evidence concerning students' progress towards learning outcomes; (2) the teachers' and students' reflections on the feedback of this information in order to enhance teaching and learning [11].

In this paper we propose a formative assessment strategy based on visualisation techniques to support teachers' awareness and reflection in University learning contexts that integrate technology enhanced learning activities in the curriculum.

2 The LearnWeb Formative Assessment Extension as a Means to Support Awareness and Reflection

LearnWeb¹ is an online learning environment, which allows users to share and collaboratively work on user-generated resources either uploaded from the desktop, or collected from the web [5-6, 9]. In order to make the knowledge processes explicit both for teachers and for students granting them more agency in learning activities, the LearnWeb system has been designed in keeping with the Learning by Design approach [8,10,14]. The LearnWeb Design Framework (Fig. 1) has been demonstrated to be effective in supporting reflection and collaboration in the co-design of courses in the past [7-10]. Now we want to enhance the framework by providing tools that allow teachers to evaluate students' work throughout their learning pathway.

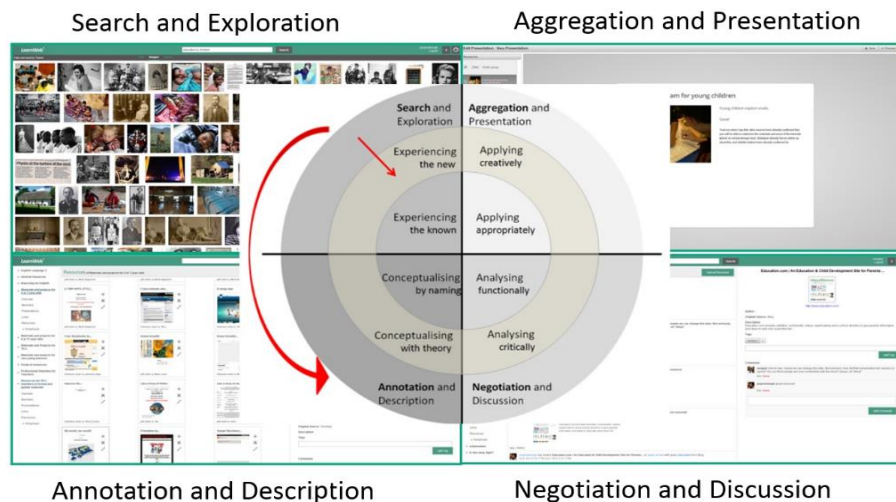


Fig. 1. Web2.0 features to the LearnWeb Design framework (multi-tier model)

2.1 Design of the LearnWeb Formative Assessment Extension

In order to provide the teacher with evidence of each student's (or group's) involvement in the various knowledge processes when carrying out the learning tasks, we need to explicitly associate and display the logged data that corresponds to each activity (see Table 1). In this way, the teacher can refer back to the original framework and course design, and monitor the students' performance in line with the expected learning goals.

In order to address the needs of different scenarios the LearnWeb Formative Assessment extension has been designed from three main perspectives: (i) a course perspective, where the teacher has an overview of a specific course and can make comparisons between/among classes, (ii) a class perspective, where the teacher can moni-

¹ <http://learnweb.13s.uni-hannover.de>

tor and compare the activities of small groups within the same class, and (iii) a personal perspective where the teacher can visualise information about a specific user.

Table 1. Phases of the LearnWeb Design Framework and Logged activities

LearnWeb Phases	Logged activities
<i>Search and exploration</i> (Experiencing)	Searching, Download, Open resource, Add resource, Delete resource, Create group, Group joining, Group leaving
<i>Annotation and description</i> (Conceptualising)	Tagging resource, Ratings resource, Edit resource, Comments, Deleting comments
<i>Negotiation and discussion</i> (Analysing)	Text from comments visualised with WordWanderer ²
<i>Aggregation and presentation</i> (Applying)	Grouping resources and presentation functionality

Each phase on the user interface is located in a different tab so as to visualise the data relating to each phase in a specific context (see Fig. 2 (1)). The visualisation of each of these perspectives takes into account the activities carried out by students aggregated with four groups related to the four LearnWeb Design Framework features as described in Table 1 (see Fig. 2 (2)), thus enabling teachers to analyse the factors involved in the various learning tasks. A specific learning scenario is described in the following section so as to provide a preliminary evaluation of the teacher's feedback concerning the usefulness of the visualisation of data to support teaching strategies and practice.

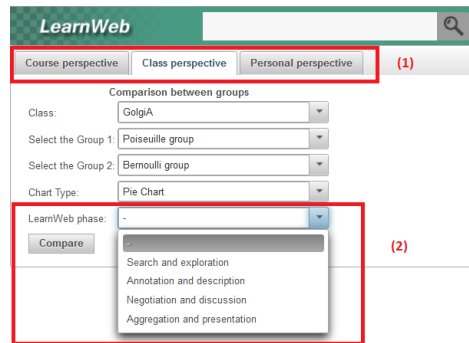


Fig. 2. LearnWeb Formative Assessment extension interface

For the implementation of the Formative Assessment extension, we carried out frequency analysis and built the charts using the PrimeFaces³ library.

In agreement with the teacher, we started with the visualisation of the data collected in previous years so as to provide a diachronic overview for the teacher who will be able to compare the performances of different courses and reflect on the course design

² <http://wordwanderer.org/>

³ <http://primefaces.org/>

of future editions [4]. The objective is to evaluate the work carried out in the past and improve future teaching/learning experiences by personalising and adapting [11].

2.2 The LearnWeb Formative Assessment Extension in Practice

During the Academic Year 2011-2012 we carried out a study at the University of Pavia, in Italy that involved 284 first-year medical students divided into five classes: GolgiA (85 students), GolgiB (71), GolgiC (44), HarveyD (50) and HarveyE (34).

The syllabus was based on English linguistics and focused on text-based studies of (bio)-medical English. Students were expected to learn about multimodal theory and how to carry out multimodal text analysis, that is, the study of printed, website, digital and film texts in English and the ways in which these texts are used in different medical and biomedical contexts [1]. For their project work, students were required to carry out research in groups of 8-12 members on the topic “health/bio-medical/scientific education through entertainment of young children and teenagers” and create a corpus of at least 50 websites. The work entailed the annotation of their search trajectories (failures and successes) and the use of the LearnWeb options to communicate with their group members and exchange information and comments.

At the time of the described scenario, the Formative Assessment Extension was not yet available, and the teacher had to explore the work done by students by browsing through the various groups. Using the current version of the system, it is now possible to obtain a rapid overview of student contributions with various levels of detail.

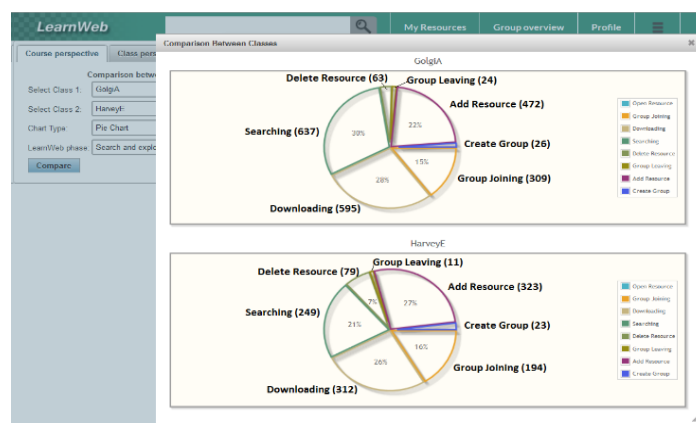


Fig. 3. Course perspective (Comparison between classes) – Search and Exploration

(1) *Course Perspective* – the interface provides two search fields where the teacher can select two classes to be compared and choose different types of graphs to visualise the data. Fig. 3 presents a comparison between the HarveyE and the GolgiA class as regards the first pedagogical phase (*Search and Exploration*). Students in HarveyE searched and added more resources than the students in GolgiA. Since the project work task was the same for all groups (i.e. build a corpus of at least 50 websites), the teacher might want to intervene and invite the GolgiA groups to speed up the work.

The comparison is about the type of activities carried out by students in the two classes and can be between courses of the past, or courses functioning at the same time. In the first case (past courses), the teacher can see whether the current class is performing better or worse than the previous class. Consequently, the teacher can reflect on how to improve the course design or introduce better explanatory strategies for students by using notifications to communicate with them and give support. In the second case (current courses), the system visualises the actual value at a specific time so that the teacher is constantly up to date on how the students are working in the platform. For example, if one class is performing at a slower rate than another in the same course, the teacher can send a notification and a request to the group leader to speed up the work. This strategy can be useful when the teacher wants to stimulate competition.

(2) *Class Perspective* – the teacher can choose a specific class in the course and select two sub-groups to be compared. In the GolgiA class for example, the results of the comparison between the activities of the Euronics group and the Children's genes group in the *Search and Exploration* phase are very similar. Whilst in the *Annotation and Description* phase (Fig. 4) we notice that a larger number of tags were added by the members of the Euronics group, the students in the Children's genes group were more active in commenting and editing resources.

The results show how the two groups use a different strategy to conceptualise and categorise contents, thus helping the teacher to understand the learning behaviour and evaluate the group work accordingly. The teacher might decide to discuss the findings with students and reflect on their behaviour during the course or the final exam.

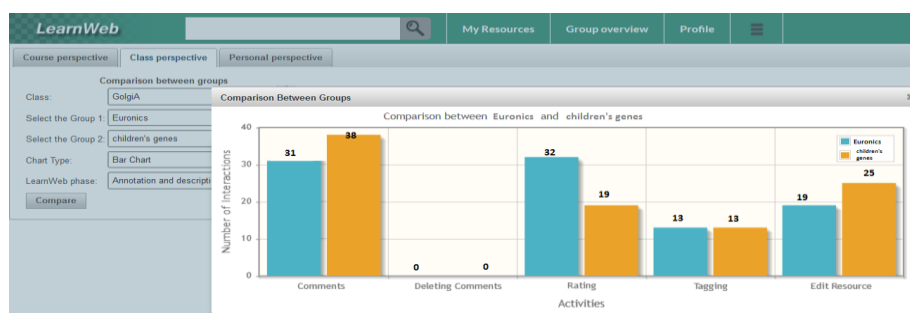


Fig. 4. Class perspective (group overview) – *Annotation and Description*

(3) *Personal Perspective* – The window provides two search fields where the teacher can select a specific class and a specific student in that class. The resulting graph shows the number of activities carried out by the student throughout the course (see Fig. 5). This information can help the teacher to better understand the performance of each student and provide personalised feedback, for example according to: (i) the specific role (e.g. group leaders can/should carry out additional activities compared to the other group members), (ii) the given task (e.g. the teacher can encourage the slower students to carry their weight).

Fig. 5(a) shows an example of this analysis, where the teacher investigates the profile of a student (anonymized in the picture for privacy reasons). The student mainly searched and added resources; strangely no traces for Open resources are logged. This could mean that the student added materials to the group only relying on the title, without checking the content, and the teacher might want to investigate this student's behaviour further. Fig. 5(b) shows the traces of the same user as regards the pedagogical phase of *Annotation and Description*. He mainly commented resources, but he also used ratings and tags to annotate resources. According to the tasks assigned in the course, the teacher can judge whether the student is behaving as expected, and decide to send him specific feedback or additional directions.

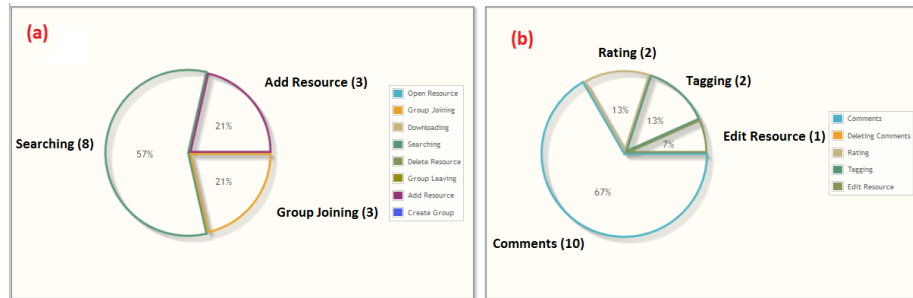


Fig. 5. Personal perspective (User Analysis) - (a) *Search and Exploration*, (b) *Annotation and Description*

Such visualisations are useful to detect an increase or decrease in student participation in learning activities and can encourage the teacher to restructure some tasks or to adopt different pedagogical strategies if deemed necessary. Prompt intervention can be a crucial factor in determining the success or failure of a course. Using the Formative Assessment extension, the teacher is made aware of the dynamics that are taking place in the course and can speedily intervene in order to raise interest when it appears to be waning. As matter of fact, the teacher in Pavia evaluated the prototype of the system and confirmed its potential: “it has practical applications which can save time and allow for the constant realignment of the teaching strategies with the learning goals”.

3 Conclusions and Future Work

The LearnWeb Formative Assessment extension is designed to offer a common basis for various stakeholders: for teachers to reflect on the teaching practices and refine their pedagogical strategies; for students to keep track of their personal progress and measure their performance in comparison with their peers; for researchers to realise what functionalities work better to support specific learning tasks and improve the system.

While some components of the technical approach are already available, others are under development. For the moment we focused on developing tools to support teach-

er awareness and to facilitate monitoring and mentoring activities. In the future, we will develop the assignment and recommendation component that includes the user interface for the learner. Another step will be the addition of a temporal dimension in order to give a diachronic visualisation of group interactions. The impact of the feedback provided through the proposed extension on student learning pathways will be investigated in future projects both in Italy and in Brazil. An extended study will be carried out with the aim of analysing how feedback is perceived by students and the impact it has on moulding the next learning stages.

4 References

1. Baldry, A., Thibault, Paul J. Multimodal transcription and text analysis. A multimodal toolkit and coursebook. London and New York: Equinox (2006).
2. Charleer, S., Santos, J. L., Klerkx, J., Duval, E.: LARAe: Learning Analytics Reflection & Awareness environment. In Milos Kravcik et al. (Eds.). In: *Proceedings of the ARTEL 2014 Workshop*, vol. 1238, pp. 85–87.
3. Govaerts Sten, Verbert Katrien, Klerkx Joris, Erik Duval (2010). Visualizing Activities for Self-reflection and Awareness. *Advances in Web-Based Learning (ICWL 2010)*.
4. Greller, W., Drachsler, H.: Translating Learning into Numbers: A Generic Framework for Learning Analytics. *Educational Technology & Society*, 15 (3), 42–57 (2012).
5. Marenzi, I., Nejd, W.: I search therefore I learn. Supporting active and collaborative learning in language teaching. In: A. Okada, T. Connolly, P. Scott (eds.): *Collaborative Learning 2.0: Open Educational Resources*. IGI Global, pp.103–125 (2012).
6. Marenzi, I., Zerr, S.: Multiliteracies and active learning in CLIL: the development of LearnWeb2.0. *IEEE Transactions on Learning Technologies (TLT)*. Los Alamitos, CA, USA, 5(4), 336–348 (2012).
7. Marenzi, I.: A multiliteracies approach for supporting language learning courses at university level. In: J. Jovanovic & R. Chiong (eds.): *Technological and Social Environments for Interactive Learning*. Santa Rosa, CA: Informing Science Press, 249–276 (2013).
8. Marenzi, I., Kantz, D.: ESP course design – a multiliteracies approach. In: *Reshaping Learning: Transforming Education through the Fusion of Learning and Technology*, Proceedings of the 13th ICALT Conference (2013).
9. Marenzi, I.: Interactive and collaborative supports for CLIL: towards a formal model based on digital literacy. In: R. Kupetz & C. Becker (eds.): *Content and Language Integrated Learning (CLIL) by Interaction*. Frankfurt am Main: Peter Lang, 75–99 (2014).
10. Marenzi, I.: Multiliteracies and e-learning2.0. *Foreign language pedagogy content- and learner-oriented*, Vol.28. Frankfurt am Main: Peter Lang (2014).
11. Taibi, D., Kantz, D. and Fulantelli, G.: Supporting formative assessment in content and language integrated learning: the MWSWeb platform. In: *IJTEL*, 6,(4), pp.361–379 (2014).
12. Vozniuk, A., Triana, M. J. R., Holzer, A., Govaerts, S., Sandoz, D., Gillet, D.: Contextual Learning Analytics Apps to Create Awareness in Blended Inquiry Learning. In: *Proceedings of the 14th ITHET* (2015).
13. Wang, T. H.: What strategies are effective for formative assessment in an e-learning environment? In: *Journal of Computer Assisted Learning*, 23(3), 171–186 (2007).
14. Yelland N., Cope B., Kalantzis M.: Learning by Design: creating pedagogical frameworks for knowledge building in the twenty-first century. *Asia-Pacific Journal of Teacher Education*, 36(3), 197–213 (2008).

Deploying Learning Analytics for Awareness and Reflection in Online Scientific Experimentation

Alexander Mikroyannidis¹, Aitor Gomez-Goiri¹, John Domingue¹, Christos Tranoris²,
Daan Pareit³, Jono Vanhie-Van Gerwen³, Johann M. Marquez-Barja⁴

¹Knowledge Media Institute, The Open University, United Kingdom
{Alexander.Mikroyannidis, Aitor.Gomez-Goiri, John.Domingue}@open.ac.uk

²University of Patras, Greece
tranoris@ece.upatras.gr

³iMinds, Belgium
{daan.pareit, jono.vanhie}@intec.ugent.be

⁴Trinity College Dublin, Ireland
marquejm@tcd.ie

Abstract. Recent trends in online learning, most notably Massive Open Online Courses (MOOCs) and Learning Analytics, are changing the landscape in the education sector by offering learners with access to free learning materials of high quality, as well as with the means to monitor their progress and reflect on their learning experiences. This paper presents FORGE, a European initiative for online learning and experimentation via interactive learning resources. FORGE provides learners and educators with access to world-class experimentation facilities and high quality learning materials. Additionally, the deployment of Learning Analytics in the FORGE learning resources aims at supporting awareness and reflection both for learners and educators.

Keywords: Learning Analytics; Interactive learning resources; Widgets; Open Educational Resources; Massive Open Online Courses.

1 Introduction

Higher education is currently undergoing major changes, largely driven by the availability of high quality online materials, also known as Open Educational Resources (OERs) [1]. The emergence of OERs has greatly facilitated online education through the use and sharing of open and reusable learning resources on the web. The OER initiative has recently culminated in MOOCs (Massive Open Online Courses) delivered via providers such as Udacity¹, Coursera², edX³ and FutureLearn⁴. MOOCs have very quickly attracted large numbers of learners; for example FutureLearn has attracted more than 1 million registered learners worldwide since its launch in 2013, with over 2.2 million course sign-ups. FutureLearn has recently

¹ <http://www.udacity.com/>

² <https://www.coursera.org/>

³ <https://www.edx.org/>

⁴ <https://www.futurelearn.com>

launched the largest ever MOOC, with over 400,000 enrolments of learners for a British Council course preparing for an English language test.⁵

Another recent development in technology-enhanced learning is the “*measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs*”⁶ via Learning Analytics methods. The field of Learning Analytics is rapidly developing and it gradually shifts away from technology towards an educational focus [4]. It is essentially a “*bricolage field, incorporating methods and techniques from a broad range of feeder fields: social network analysis (SNA), machine learning, statistics, intelligent tutors, learning sciences, and others*” [9].

Following these trends, the European project FORGE (Forging Online Education through FIRE)⁷ is developing multimodal interactive OERs that enable online experimentation using FIRE facilities. FIRE (Future Internet Research and Experimentation)⁸ is a pan-European network of testbeds, including cloud computing services, wireless technologies testbeds, such as Wi-Fi, sensor networks, or LTE, infrastructures for High Performance Computing, and more. FORGE is specifying development methodologies and best practices for offering open courseware and online experimentation facilities to learners, related primarily to communications and IT.

One of the main goals of FORGE is to enable educators and learners to access and actively use FIRE facilities in order to conduct scientific experiments. We thus follow a constructivist approach to education where learning takes place by students creating artefacts rather than assuming the passive role of a listener or reader. Our approach is based on a wide range of studies that have shown that with the right scaffolding competent learners benefit greatly from *constructivist* or *learning-by-doing* approaches [3, 6, 7]. The experiment-driven approach of FORGE contributes to fostering constructivist learning by turning learners into active scientific investigators, equipped with world-class experimentation facilities.

FORGE is enabling students to set up and run FIRE experiments from within rich related learning content embedded as widgets inside interactive learning resources. Widgets are powerful software components that can be reused across different learning contexts and for different educational purposes. The portability of widgets as bespoke apps that can be embedded into a variety of online environments ensures that the FORGE learning solutions implemented as widgets have a high reusability factor across multiple learning domains and online learning technologies. Within FORGE, widgets enable educators and learners to access and actively use Future Internet facilities as remote labs in order to conduct scientific experiments. Learners and educators can setup and run Future Internet experiments from within rich related learning content embedded as widgets inside interactive eBooks and Learning Management Systems (LMSs).

⁵ <https://about.futurelearn.com/press-releases/futurelearn-delivers-the-largest-mooc-ever-as-nearly-400000-learners-convene-for-english-language-learning/>

⁶ 1st International Conference on Learning Analytics and Knowledge – LAK 2011
<https://tekri.athabascau.ca/analytics/>

⁷ <http://www.ict-forge.eu>

⁸ <http://www.ict-fire.eu>

The remainder of this paper is organised as follows. Section 2 presents the lifecycle of the FORGE learning resources. Section 3 presents the deployment of Learning Analytics in the FORGE widgets for supporting awareness and reflection. Finally, the results of this work are summarised in Section 4.

2 Course lifecycle

There are different available methodologies for deploying remote and/or virtual lab/courses in the literature, each of them targeting different facilities and tools. Bose [2] presents a methodology for creation of a virtual lab. This approach targets the Virtual labs project and guides the lab creator to deploy a lab within the scope of such project. In a similar basis, Frerich et al [5] present a lab lifecycle with the Excellent Teaching and Learning in Engineering Sciences (ELLI) project. Both mentioned projects, focus on virtual labs (software/simulation-based) rather than remote experimentation labs (experimentation-based) [8]. We focus on remote experimentation performed on top of FIRE facilities. The lifecycle of a FIRE-enabled course consists of the following steps:

- *Specifying course requirements.* In this step, the educator specifies the overall course requirements, including the learning objectives of the course, the required skills, the skills that will be acquired by learners after completing this course, the course timeframe, the number of learners and the method of delivery (online, face-to-face, or blended).
- *Identifying FIRE facilities.* In this step, the educator identifies the FIRE facilities that will suit the course requirements. These FIRE facilities will be selected based on their suitability for the learning objectives of the course and its associated skills. The number of learners and timeframe will also play a role in selecting a FIRE facility based on its availability.
- *Authoring educational content.* The educational content that will form the learning pathway of the course is authored in this step. Finding open educational resources that are suitable for the course is quite important, as these can be reused, adapted and repurposed to fit the course learning objectives and other requirements.
- *Integration of FIRE facilities and content.* In this step, the selected FIRE facilities and the educational content of the course are integrated in order to form the complete learning pathway. FIRE facilities are commonly integrated as widgets, which can be reused across different learning activities for different learning purposes.
- *Deployment.* The deployment of the course for delivery to learners is performed in this step. Depending on the course requirement for delivery (online, face-to-face, or blended), the educator can deploy the course within a LMS or as an interactive eBook.
- *Evaluation.* In this step, the educator evaluates the success of the course, based on qualitative feedback received from learners via surveys and questionnaires, or via quantitative data collected by Learning Analytics tools that track the interactions of learners with the course materials and with each other.

- *Reflection and adaptation.* By analysing the qualitative and quantitative data collected from the evaluation of the course, educators have the opportunity to reflect and draw some conclusions about potential adaptations and improvements to the course.

3 Deployment of Learning Analytics for awareness and reflection

With Learning Analytics it is possible to obtain valuable information about how learners interact with the FORGE courseware, in addition to their own judgments provided via questionnaires. In particular, we are collecting data generated from recording the interactions of learners with the FORGE widgets inside eBooks and online courses. We are tracking *learner activities*, which consist of interactions between a *subject* (learner), an *object* (FORGE widget) and are bounded with a *verb* (action performed). We are using the Tin Can⁹ API (also known as xAPI) to express and exchange statements about learner activities, as well as the open source Learning Locker¹⁰ LRS (Learning Record Store) to store and visualise the learner activities.

Learner activities performed on the FORGE widgets typically include the initialisation of an experiment, setting the parameters of the experiment and, finally, completing the experiment. Therefore, the learner activities captured by the FORGE widgets use the following types of xAPI verbs:

- *Initialised*¹¹: Formally indicates the beginning of analytics tracking, triggered by a learner “viewing” a web page or widget. It contains the (anonymised) learner id and the exercise/widget that was initialized.
- *Interacted*¹²: Triggered when an experiment is started by the learner, containing the learner id, the exercise and possible parameters chosen by the learner. These parameters are stored in serialized JSON form using the result object, as defined by the xAPI.
- *Completed*¹³: The final verb, signalling completion of an exercise by the learner. We can also include the duration that a learner took to perform the experiment, formatted using the ISO 8601 duration syntax following the xAPI specifications.

More specialised learner activities are also recorded by the FORGE widgets depending on the functionalities offered by each widget. These statements are collected in the Learning Locker, which features a simple but effective dashboard, giving a quick overview of the activities over time, as well as the most active users and activities, as shown in Figure 1.

⁹ <http://tincanapi.com/>

¹⁰ <http://learninglocker.net/>

¹¹ <http://adlnet.gov/expapi/verbs/initialized>

¹² <http://adlnet.gov/expapi/verbs/interacted>

¹³ <http://adlnet.gov/expapi/verbs/completed>

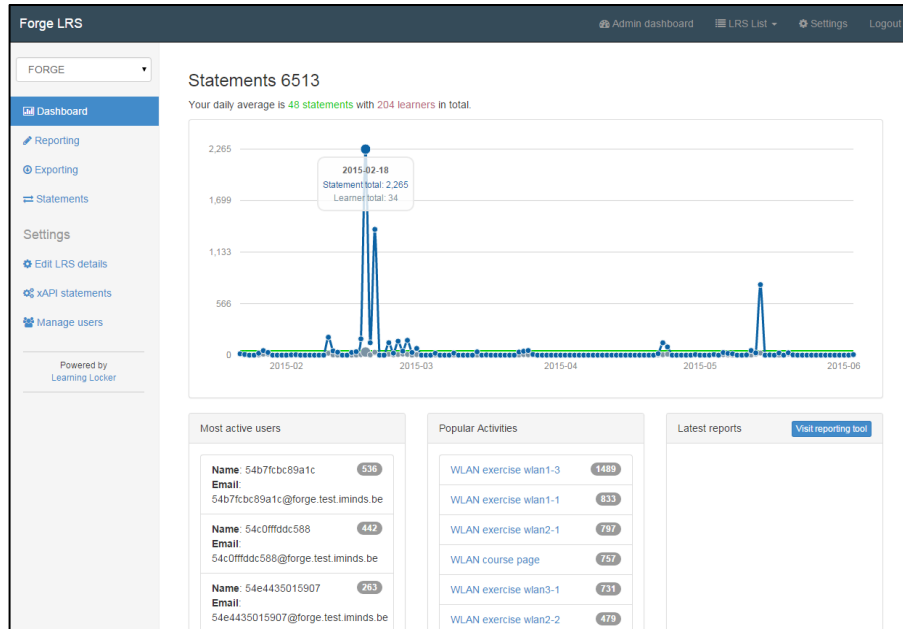


Figure 1: A screenshot of the FORGE LRS offering an overview of the captured learner activities.

The deployment of Learning Analytics within FORGE is aiming at facilitating awareness and reflection both for learners and educators. According to [10], educators need to ensure that learners are provided with (i) specific tasks, (ii) multiple learning resources, as well as (iii) learning supports (conative, scaffolds and social), in order to increase the potential for computer-mediated technologies to serve as catalysts in promoting critical reflection and meaningful learning. In the context of FORGE, learning activities for experimentation play the role of tasks; multiple resources are offered by the FORGE learning materials and other related OERs. Finally, Learning Analytics tools and visualisations provide learning supports in the form of scaffolds and social supports, as explained in the following paragraphs.

FORGE provides learners with Learning Analytics dashboards in order to raise their awareness of their learning activities by providing an overview of their progress or social structures in the course context. Learners are offered with detailed records of their learning activities, thus being able to monitor their progress and compare it with the progress of their fellow learners. Additionally, the Learning Analytics dashboards targeted to educators provide an in-depth overview about the activities taking place within their courses, thus making the educators aware of how their courses and experimentation facilities are being used by their students.

In order to improve the ways we facilitate awareness and reflection for learners and educators, we are developing further ways of analysing and visualising the captured Learning Analytics data. Our goal is to help educators better understand the use of experimentation facilities by their students, as well as to allow learners to compare their use of the experimentation facilities with that of other learners. Towards this

goal, we are developing graph models in order to visualise the different sequences of steps carried out by learners when conducting an experiment via the FORGE widgets. Figure 2 shows the first four steps of the different sessions recorded by the PT Anywhere¹⁴ network simulation widget. This model is customised by the learner or the educator, who specifies the different levels to visualise, i.e. the number of steps or actions to be displayed. In this particular model, the different states for each level apply to a network device, which is part of a network simulation experiment, and refer to its creation (ADD), removal (DEL), update (UPD), connection (CONN) and disconnection (DISCONN). Additionally, a NOOP state is used to represent the lack of action in sessions with fewer actions recorded than levels shown.

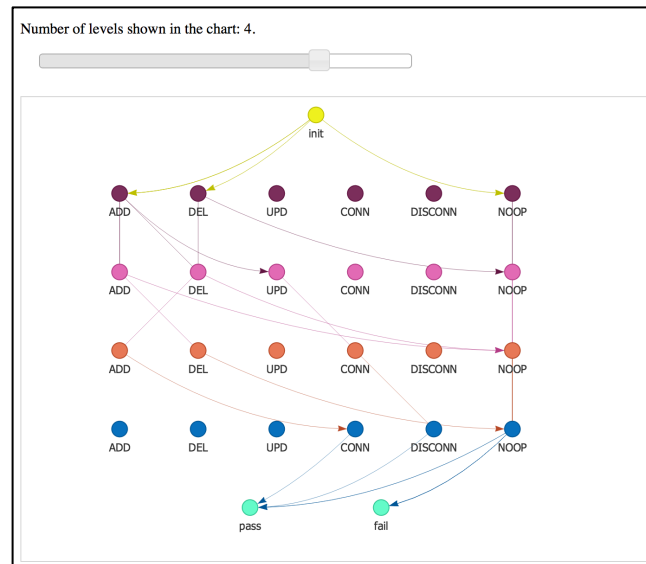


Figure 2: A model of sequences of user interactions recorded within a FORGE widget.

These models allow educators to get a more detailed view of how learners conduct experiments using the FORGE widgets. Learners can also use these models to replay their sequence of interactions with the FORGE widgets, as well as view the sequences of interactions of other learners. On top of providing awareness, these models also enable learners to reflect on their learning process, for example by being able to compare the sequences of interactions of other learners with theirs, as well as by comparing their experimentation results with those of their peers. Additionally, educators can reflect on the design of the experimentation facilities and the associated learning materials by studying usage patterns that can reveal common difficulties that learners have in conducting experiments. Educators can also provide suggested sequences of interactions to their students as a means of scaffolding their experimentation tasks.

¹⁴ <http://pt-anywhere.kmi.open.ac.uk>

4 Conclusions

This paper presented the FORGE approach for online scientific experimentation, which is based on the use of widgets and interactive learning resources. Learning Analytics data are collected by recording the interactions of learners with the FORGE widgets and analysed in order to understand how learners conduct scientific experiments using the FORGE learning resources. Our work on Learning Analytics is ongoing and is targeting both learners and educators. In particular, we are using Learning Analytics tools and visualisations as learning supports in the form of scaffolds and social supports for learners. Additionally, we aim at facilitating educators in reflecting on the design of their courses based on the collected data about the use of the experimentation facilities.

Acknowledgments. This work has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreements no. 610889 (FORGE).

References

- [1] Atkins, D. E., Brown, J. S., and Hammond, A. L. A Review of the Open Educational Resources (OER) Movement: Achievements, Challenges, and New Opportunities. The William and Flora Hewlett Foundation 2007.
- [2] Bose, R. *Virtual Labs Project: A Paradigm Shift in Internet-Based Remote Experimentation*. Access, IEEE, 2013. **1**: p.718-725.
- [3] De Jong, T., "Scaffolds for computer simulation based scientific discovery learning", in *Dealing with complexity in learning environments*, Elen, J. and Clark, R. E., Eds., London Elsevier Science Publishers, 2006, p. 107-128.
- [4] Ferguson, R. *Learning analytics: drivers, developments and challenges*. International Journal of Technology Enhanced Learning, 2012. **4**(5-6): p.304-317.
- [5] Frerich, S., Kruse, D., Petermann, M., and Kilzer, A. *Virtual Labs and Remote Labs: Practical experience for everyone*. In *Proceedings of the IEEE Global Engineering Education Conference (EDUCON)*. 2014. Istanbul, Turkey, p.312-314.
- [6] Hakkarainen, K. *Emergence of Progressive-Inquiry Culture in Computer-Supported Collaborative Learning*. Science and Education, 2003. **6**(2): p.199-220.
- [7] Kasl, E. and Yorks, L. *Collaborative inquiry for adult learning*. New Directions for Adult and Continuing Education, 2002. **2002**(94): p.3-12.
- [8] Marquez-Barja, J. M., Kaminski, N., Paisana, F., Tranoris, C., and DaSilva, L. A. *Virtualizing testbed resources to enable remote experimentation in online telecommunications education*. In *Proceedings of the IEEE Global Engineering Education Conference (EDUCON)*. 2015. Tallinn, Estonia, p.836-843.
- [9] Siemens, G. *The Journal of Learning Analytics: Supporting and Promoting Learning Analytics Research*. Journal of Learning Analytics, 2014. **1**(1): p.3-5.
- [10] Strampel, K. and Oliver, R. *Using technology to foster reflection in higher education*. In *Proceedings of the ICT: Providing choices for learners and learning. Proceedings ascilite Singapore 2007*. 2007.